AD

Report SE-89-03

AD-A214 644

APPLICATION OF HIGH-RATE CUTTING TOOLS

Manufacturing Methods & Technology Project No. 6828248

John Moriarty
Project Engineer

March 1989

Rock Island Arsenal
Rock Island, IL 61299-5000

TECHNICAL REPORT

ROCK ISLAND ARSENAL
ROCK ISLAND, ILLINOIS 61299-5000

DISCLAIMER

The citation of specific products or the use of trade names or manufacturers' names does not constitute an endorsement or approval by the Department of Army.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY 2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	3 DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
4. PERFORMING ORGANIZATION REPORT NUMBER(S) SE-89-03	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Science and Engineering Direct. 6b OFFICE SYMBOL (If applicable) SMCRI-SE	7a NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Rock Island Arsenal Rock Island, IL 61299-5000	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING / SPONSORING ORGANIZATION 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO
PW, A3297	6828248		

11. TITLE (Include Security Classification)

Application of High-Rate Cutting Tools

12. PERSONAL AUTHOR(S)

Moriarty, John L., Jr.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final Technical Report	FROM 1982 TO 1988	1989, March 30	141

16. SUPPLEMENTARY NOTATION

The citation of specific products or the use of trade names or manufacturer's names does not constitute an endorsement or approval by the Department of Army

17. COSATI CODES

FIELD	GROUP	SUB-GROUP
13	09	
13	08	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

Cutting Tools, Turning, Coated Carbide Inserts, Carbide Tools, Machine Shop Practice, Tool Life, Machinability, High Rate Metal Removal

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Widespread application of the newest high-rate cutting tools to the most appropriate jobs is slowed by the sheer magnitude of developments in tool types, materials, workpiece applications, and by the rapid pace of change. Therefore, a study of finishing and roughing sizes of coated carbide inserts having a variety of geometries for single point turning was completed. The cutting tools were tested for tool life, chip quality, and workpiece surface finish at various cutting conditions with medium alloy steel. An empirical wear-life data base was established, and a computer program was developed to facilitate technology transfer, assist selection of carbide insert grades, and provide machine operating parameters. A follow-on test program was implemented suitable for next generation coated carbides, rotary cutting tools, cutting fluids, and ceramic tool materials. Computer program algorithms were used to quantify comparisons among different manufacturer's tools. Benefits realized are a selective and reduced tool inventory, increased productivity, improved part quality, and more extended, accelerated application of new tooling.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
Richard Kalkan, Jr.	(309) 782-7873	SMCRI-SEM-T

DD Form 1473, JUN 86 Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

This page intentionally left blank.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

The author wishes to express sincere appreciation to numerous individuals and organizations who have contributed to the success of this project and the implementation of the Rock Island Arsenal tool testing program results. Recognition is due the following: SMCRI-AOE-M, SMCRI-AOE-N, SMCRI-AOF-TS, and SMCRI-AOF-TA, all organizations in the Rock Island Arsenal Operations Directorate, for assisting in the procurement of insert grades, providing workpiece materials, operating test equipment, and performing the machining operations. Contributions of Ms. Mary Croscheck, who participated in collecting and analyzing the test data, and co-developed the machining data computer program, are acknowledged. Recognition is also due Dr. William Brewer, who prepared the first draft of the machining data computer program and flowchart.

This page intentionally left blank.

1.0 INTRODUCTION

At present, the rapid evolution of cutting tools and the problems subsequently affecting cutting tool selection are among the most important topics in machining. Improved tool management, including cutting tool selection, offers a practical and achievable solution to the constant demand to reduce costs and improve productivity in today's competitive manufacturing environment. It has been said, 'there is no easier less expensive, or faster way to achieve productivity and product excellence than by applying the right cutting tools to the job.' This presumes state-of-the-art equipment and trained support personnel.

The machining process and accompanying tool wear are highly complex, with many interrelated variables and dynamic reactions occurring in a very hostile environment. Experimental studies frequently are undertaken to test workpiece materials for machinability and generate operational data, but 'machinability' is difficult to define. It is not a unique material property which can be more or less easily measured like hardness or ultimate strength, as it cannot be divorced from the tool or other cutting conditions.

Early pioneering work by F. Taylor (c. 1907) established a machinability relation, an empirically derived relationship between tool life and cutting speed. Now, as in the earlier work, the nature of tool life before tool failure is recognized as probabilistic rather than deterministic. Thus, results of tool tests are influenced by rules of statistics. The variability and scatter of tool life data is an accepted fact, and scatter, itself, varies depending on machining conditions.

Throughout the recent decade, and particularly during the past 4 or 5 years, there have been major advances in the development of high productivity machining, cutting tool materials, and tool designs. New tools with thin film bonded coatings have been marketed in such numbers, with suggested applications for a wide range of work materials and conditions, that no single data base or timely reference for machining parameters exists. An increasing need for reliable technical data for efficient implementation of this new tooling was apparent.

Rock Island Arsenal's long range goals are to apply the newest cutting tools and cutting tool materials for higher productivity and lower costs and to improve tool management and inventory control. This project set the basis for meeting those goals by testing, analyzing, recommending, and applying the latest high-rate metal removal tools and materials to turning, establishing procedures for continued testing with newer tools, and creating a reliable tool life data base containing verified operating parameters for coated carbide single point turning inserts. An interactive computer program useful in identifying and ranking specific tool grades in this database to meet process requirements was also developed.

During the cutting tests at Rock Island Arsenal, the workpiece materials were not considered as test variables as care was taken to use workpiece material with very similar machinability and hardness. Care was exercised to minimize the number and sources of other possible variables during the entire study. Throughout the project, testing was carried out in random sequence, with precautions taken to ensure observations were independent of factors other than the prime variables being studied.

2.0 EXPERIMENTAL DETAILS

2.1 Workpiece

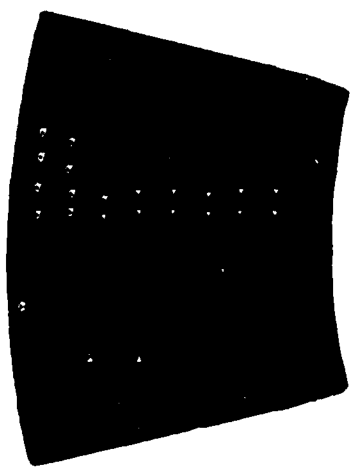
The test workpiece materials used in this study were spectro-analysis verified medium alloy steels. AISI 4140 steel (7 3/16 inch outer diameter X 1 3/16 inch wall X 36 inch long) hot rolled tubing used for finishing insert tests was heat treated, quenched, and tempered to HRC 31-33 (see Figure 1). AISI 4140 steel (same dimensions as above) and AISI 4130 (8 1/2 inch outer diameter X 1 5/8 inch wall X 36 inch long) hot rolled tubing used for roughing inset tests were heat treated, quenched, and tempered to HRC 32-35 and HRC 29-30, respectively. These steels are the most representative materials for the majority of machining at Rock Island Arsenal, and the hardnesses range from the middle to the upper end of allowances for Rock Island Arsenal products. All of the workpiece surfaces were sandblasted prior to testing and were free of mill scale and rust. Cleanup cuts were made on the outer diameters of every tube to assure that each test insert cut uniform hardness material.

2.2 Tool

The sintered carbide, indexable inserts were purchased from manufacturer's distributors. The substrate grades conformed to the U.S. 'C' classifications group C5-C8 for machining steel. Twenty-two different grades of chemical vapor deposition (CVD) coated carbides representing 13 manufacturers were tested. Each grade was either Al_2O_3-coated or multicoated. The Al_2O_3-coated grades had an Al_2O_3 exterior layer with a TiC coat just below it at the substrate interface. The multi-coated grades had a TiN exterior layer with Al_2O_3 as an intermediate, and a TiC or TaC coat at the substrate interface.

Five basic insert geometries were studied, listed here in order of both strength and lowest costs: round, square, triangle, 80 degree diamond, and 55 degree diamond. Round inserts are cheaper than squares and these are cheaper than triangles, etc. Size, which is determined by measuring the inscribed circle (IC) and thickness, affects an insert's strength, no matter what its shape. The strength of an insert is a measure of the transverse force it can withstand before fracturing. Size (IC) was chosen as a means to differentiate between those inserts applied to finishing cuts and those applied to roughing cuts. Cuts were finishing or roughing, depending upon depth of cut (DOC), i.e., with inserts having an IC of 1/2 inch, finishing tests were performed at a DOC of 0.060 inch, and with inserts having an IC of 5/8 inch and 3/4 inch, roughing tests were performed at DOC of 0.200 inch.

4140 WORKPIECE MATERIAL



1.5X

HARDNESS SURVEY HRC-31 AVE.

400X

TEMPERED MARTENSITE

FIGURE 1

Most manufacturers ofier grades listing a variety of configurations or styles of molded chi· breakers. For an equitable comparison between vendors, the recommendations in vendor literature were followed for particular chip breaker styles suitable for the DOCs and feed rates of the tests. The effectiveness of the chip breakers was examined.

Although not considered as a prime test variable, the corner radii of inserts was varied to examine the effect on tool life and surface finish.

Toolholders used in the tests had negative 5 degree back and side rake angles, regardless of insert size or geometry. Side cutting edge angles or lead angles were positive 15 degrees, 0 degrees, or negative 3 degrees and were based on the shape of insert, not on the size of insert. Holder designations were as follows:

Triangular - MTRNR - 20-4
MTRNR - 24-5

Square - MSRNR - 16-4
MSRNR - 24-6

80 degree diamond - MCGNR - 16-4
MCGNR - 20-5
MCGNR - 24-6

55 degree diamond - MDJNR - 24-4
MDJNR - 24-5

Round - MRGNR - 16-4
MRGNR - 24-6

2.3 Cutting Fluid

During the insert tests, the cutting fluid was not varied. The fluid used throughout the project was CIMCOOL 400, a synthetic lubricant marketed by Cincinnati Milacron. It was diluted 1:25 with water as recommended for turning applications with carbon steels where cooling properties are important. The fluid was applied to the backside of the workpiece tubes and directed 6 inches ahead of the cutting tool. The flow rate of the fluid was maintained at 6 gallons per minute to assure ambient temperature of the workpieces during cutting. All cutting was considered to be performed "dry," despite the adhering film of coolant on the rotating work material, as the tool-workpiece interface was at no time flooded by coolant.

2.4 Cutting Conditions

The set of machining parameters used throughout this study is shown in Table 1. Numerous cutting speed tests were conducted at each feed rate setting.

TABLE 1

CUTTING TEST MACHINING PARAMETERS

TYPE OF CUT	DOC (in.)	FEED RATES (ipr)	SPEED RANGE (SFPM)
FINISHING	0.060	0.012, 0.017, 0.020, 0.023	350 TO 700
ROUGHING	0.200	0.020, 0.023, 0.027, 0.030	250 TO 600

2.5 Tool Life Criteria

Flank wear and DOC notching both contribute toward ending useful cutting life of sintered carbide tools. During this study, width of the flank wear land (Figure 2.1) was the predominate tool life determining factor, although nose wear and rake face cratering (Figures 2.2 and 2.3) occurred as accompanying wear modes. The criteria employed for establishing tool life (T_L) were flank wear limits chosen of 0.010 inch average or 0.020 inch maximum for finishing cuts and of 0.015 inch average or 0.030 inch maximum for roughing cuts.

2.6 Tool Wear Measurement

A Gaertner toolmaker's microscope was used to measure the width of the flank wear land (VB_B), the DOC notch (VB_N), and nose wear/deformation (VB_C). The microscope was calibrated using steel shim stock in 0.001 inch increments over the range of interest from 0.001 inch to 0.030 inch. The microscope was 30X power, and the micrometer drums were divided in 0.0001 inch units, providing an estimated measurement uncertainty of ±0.0005 inch.

2.7 Equipment

The tests were carried out on the Warner and Swasey 30/60 horsepower turret lathe, saddle type chucker, style 3A, model 3500, (shown in Figure 3) dedicated to the RIA single point tool testing program. The machine tool was modified with the turret serving as the tailstock, and this was fitted with a specially constructed live-center bell end to accommodate the workpieces. The lathe was equipped with a finite step variable speed spindle. The spindle speeds were calibrated with a digital phototach covering the range of interest from 155 to 851 rpm; this was done at both 30 and 60 horsepower settings, and under both 'no load' and cutting conditions. During testing, as the workpiece diameter was reduced with successive cuts, the cutting speeds were predetermined (by calculation) in order to stay within ±3 percent of the original designated cutting speed. Other equipment included a timing clock, suitable span micrometer calipers, and a workpiece surface roughness comparator. Surface finishes were estimated (visually and tactilely) using a Number 10 Standard Ordnance Finishes Set, manufactured by Universal Machining Company.

2.8 Tool Life Test Procedures

Tool flank wear was measured at the predetermined sequence of intervals of 1, 1, 2, 2, 4, 4, 6, and 6 minutes until the average uniform wear limit or the maximum localized wear limit was reached.

Inserts remained in the toolholder while the measurements were made (Figure 4) and the accumulated wear was recorded along with elapsed time-in-cut. Individual tool wear data sheets (Figure 5) were used to document the test data and record assessments of chip quality, workpiece surface finish,

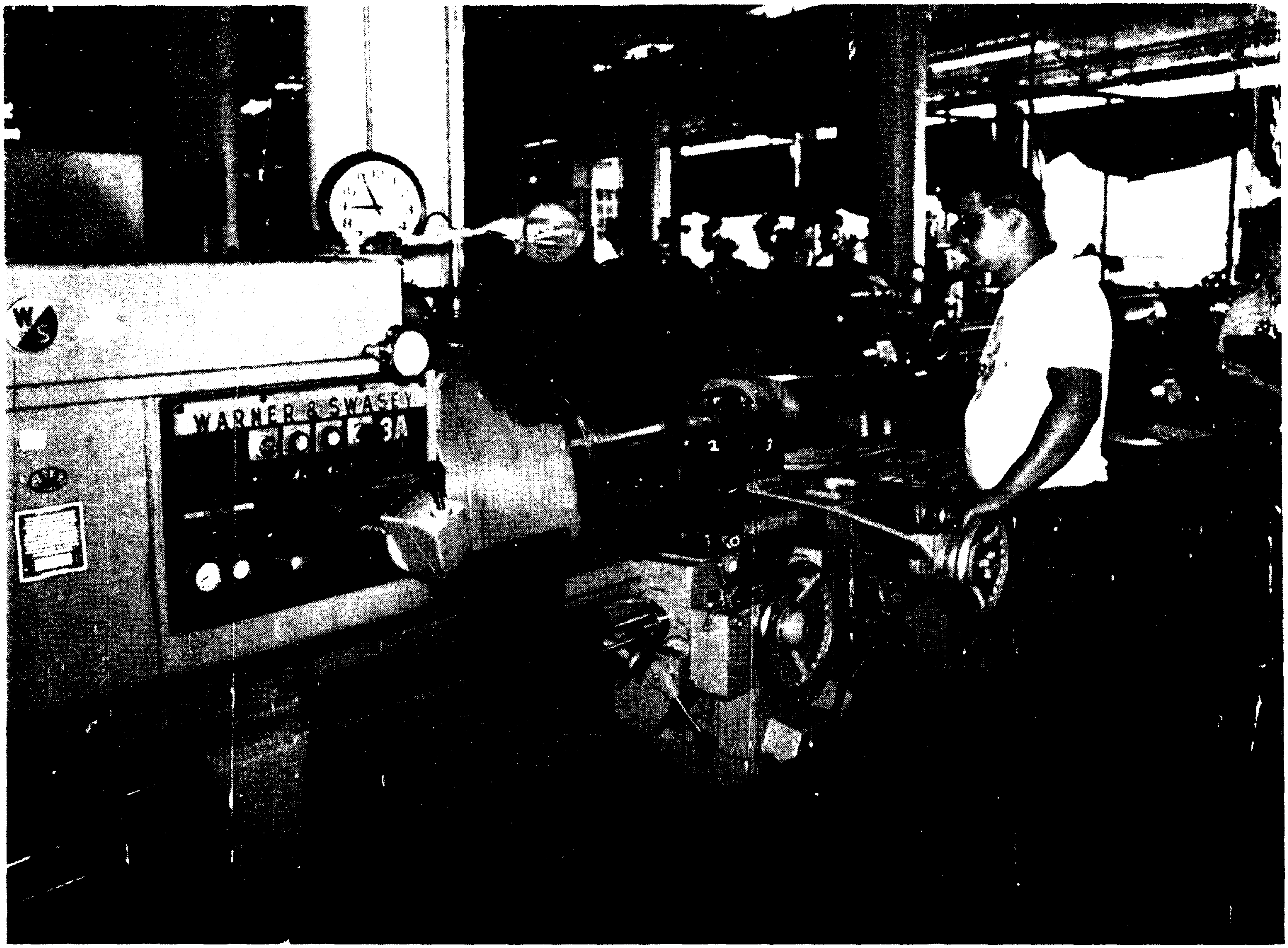
TOOL WEAR MODES

2.1 Average Flank Wear = 0.0135 in. 20X

2.2 Nose Wear & Cratering on Rake Face 20X

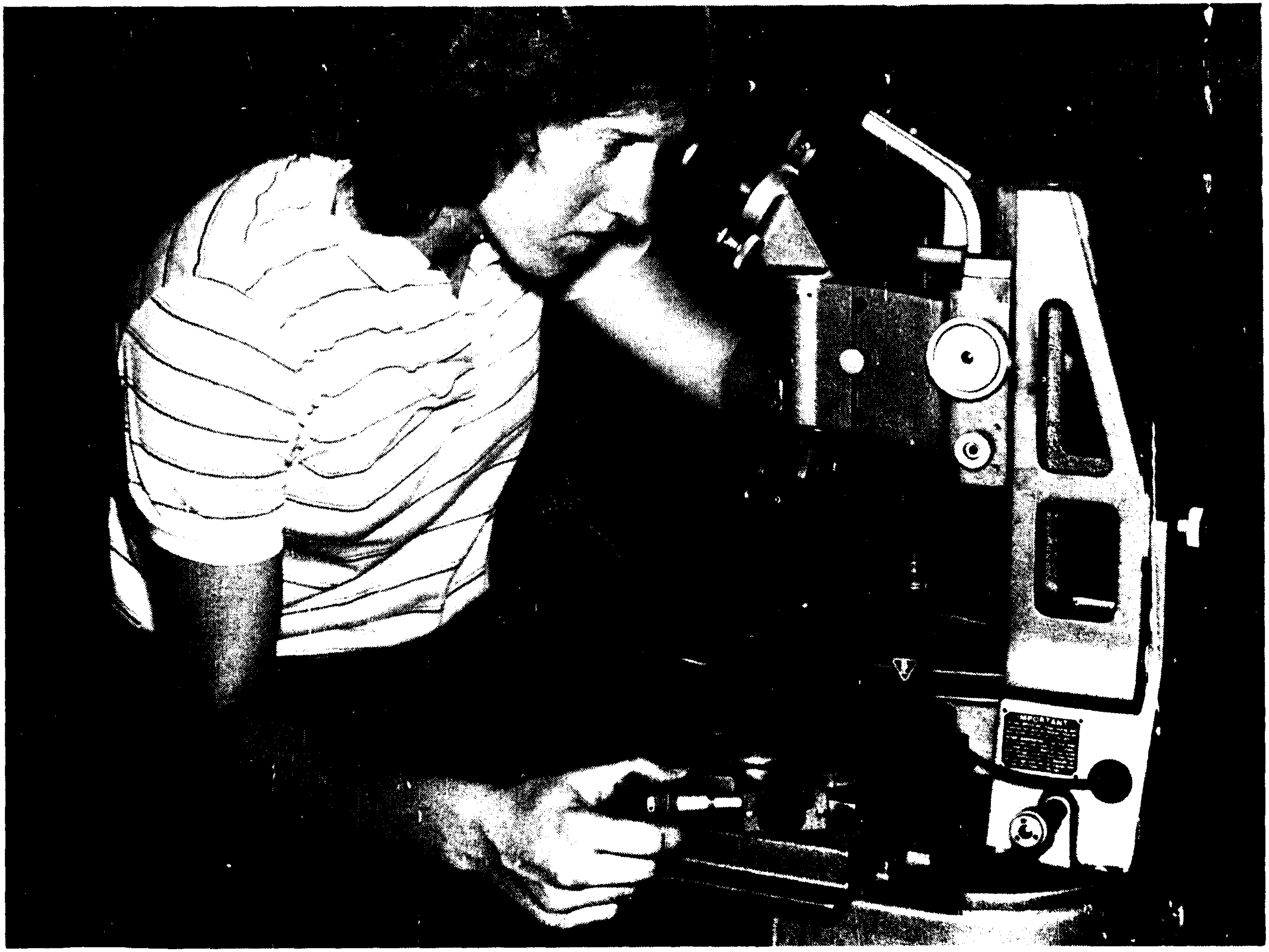
2.3 Nose Deformation & Cratering 50X

Figure 2



DEDICATED TESTING LATHE

FIGURE 3



TOOL WEAR MEASUREMENT

FIGURE 4

TOOL WEAR DATA SHEET

Cutting Tool ______ Geom. ______ Size ______ Chip Breaker ______ SCEA ______ Side Rake ______ Operator Name ______

Vendor ______ Grade ______ Coating ______ Tool Holder ______ ER ______ Back Rake ______ Date ______

Work Mat'l. ______ MBN ______ Dia. Init. ______ Final ______ Length of Cut ______ Surf.Cord. ______ Ult.Str. ______ Redn.Area ______ % ______ Strain Rate (m) ______

Form ______

Operation ______ Cut ______ Machine Tool Type ______ Mode ______ RIA No. ______ Machine hp ______ Spindle hp ______

Cutting Fluid ______ Flow Rate ______

Insert # / Edge #	Total Cutting Time (Min.)	Wk.Pc. Dia. start/finish	Speed rpm / sfpm	Feed ipr / ipm	Depth of Cut (in.)	MRR (in^3/Min.)	Wear Nose (max) (in.)	Wear Flank (max) (in.)	Wear Crater Depth (max) (in.)	Crater Edge Dist. (in.)	Crater Length / width	Machine Performance	Chip Form (Remarks)	Surface Finish HD/CT/TL	Length of cut (per edge)	Tool Wear (Sketch)	Failure Mode (Remarks)

SMC 1 FORM 900-964, 1 MAY 84 (OT)

FIGURE 5
TOOL DATA DOCUMENTATION

the machining parameters, and other observations, e.g., sparking or screeching. Wear modes were recorded for each insert edge, as was the calculation of metal removal rate. The occurrence frequency of wear modes was determined for each grade-shape combination. Catastrophic failure such as tool breakage was not found to be a problem for the regime of tested parameters.

3.0 RECORDING AND REPORTING RESULTS

Progressive flank wear measurements versus cumulative cutting times, taken at several cutting speeds (V), provided curves similar to the examples for finishing cuts shown in Figure 6. Plots of this type were the means of determining tool life (T_L) for a particular insert grade, shape, and designation run under a given set of machining conditions. Photo data displays (Figure 7) were made to document the test results for each insert cutting edge tested. Speed (Sp) and Feed (Fd) are given in units of surface feet per minute (SFPM) and inches per revolution (IPR), respectively. Figure 8 shows a typical diagram of tool life versus metal removal rate (MRR) for a family of curves plotted for different feed rates. Noted at each datum is the corresponding speed calculated in surface feet per minute and the assessment of chip quality as good (G), fair (F), or poor (P). For the same tool life, higher speeds are more economical. Consistent with Rock Island Arsenal production practice, a 10 minute tool life to achieve 0.010 inch flank wear was selected for determining the desired cutting speed (V_{10}). Figure 9 exhibits comparative results for constant feed rate tests for four different tool shapes, all of the same insert grade.

A complete tabulation of test results for both finishing size and roughing size inserts is presented in Appendices C and D, respectively.

4.0 EVALUATION AND DISCUSSION

The Taylor tool life expression, $VT^n = C$ is valid under many conditions with many materials. It relates speed (V) and tool life (T) through a constant (C) and an exponent (n), the latter two parameters varying with machining conditions. Values for C and n can be obtained graphically from plots of empirical data such as those shown in Figure 10. Here three different shapes of inserts of the same size and grade were compared. A value of the speed (V_{10}) for 10 minute tool life can be estimated from this type of linear log-log relationship.

The test data obtained during this study showed that both Al_2O_3-coated and multicoated carbide tools behaved in accordance with the Taylor equation. All experimental data was reduced using linear least squares regression analysis, and in each case the calculated statistical correlation coefficients were greater than 0.92. Table 2 displays the results of analytically fitting some typical data by this method. This table conveys how variations in feed affect speed for 10 minute tool life and chip configuration. Table 2, viewed in conjunction with Figures 8, 9, and 10, permits comparisons of metal removal

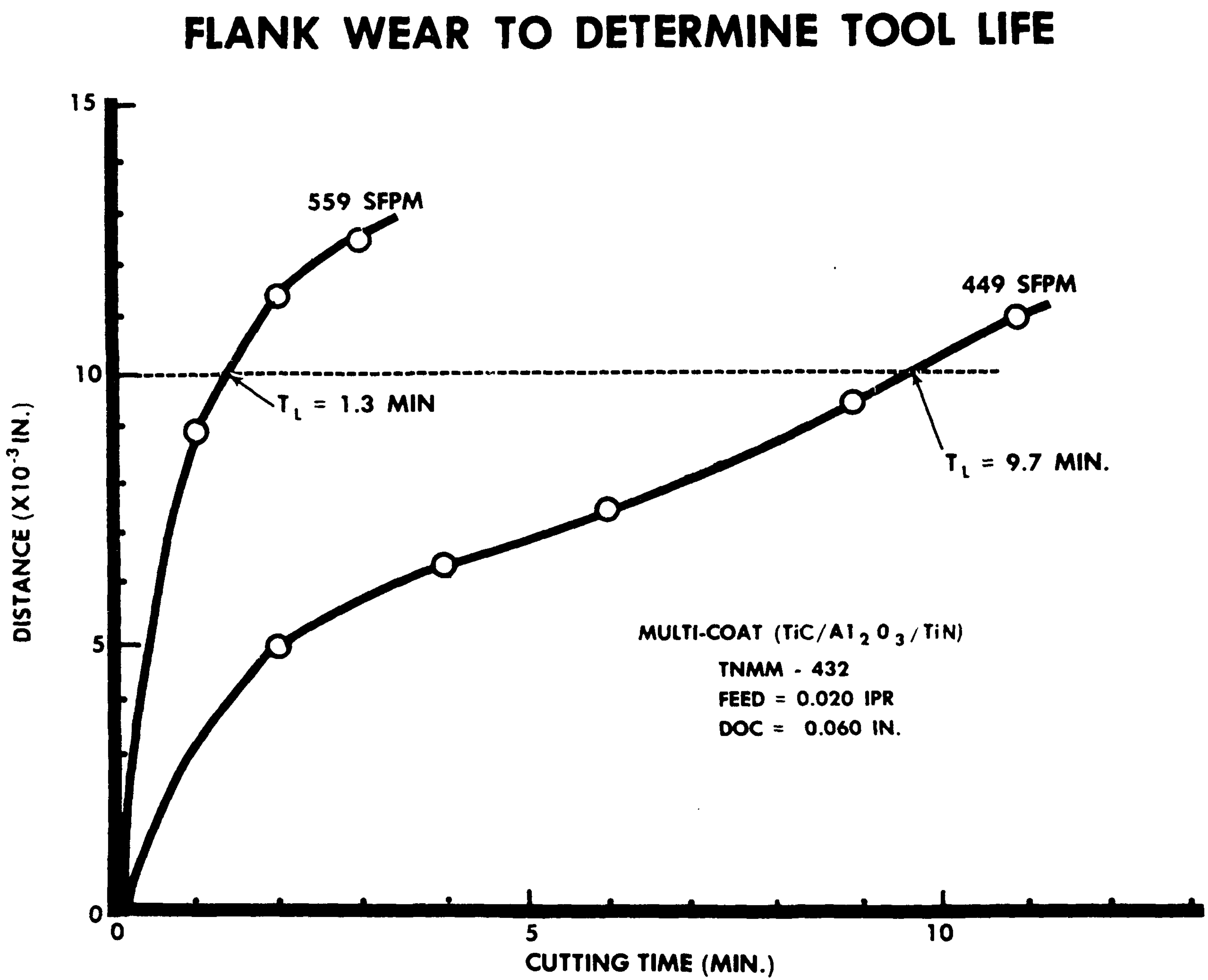

FLANK WEAR TO DETERMINE TOOL LIFE
559 SFPM
449 SFPM
T_L = 1.3 MIN
T_L = 9.7 MIN.
MULTI-COAT (TiC/Al_2O_3/TiN)
TNMM - 432
FEED = 0.020 IPR
DOC = 0.060 IN.
DISTANCE ($X10^{-3}$ IN.)
CUTTING TIME (MIN.)
0
5
10
15

FIGURE 6

PHOTO DATA DISPLAY

TNMM-432 MULTI-COAT

Sp	Fd	DOC
599	0.017	0.060 in.
sfpm	ipr	

T_L = 4.0 min. RMS = 250μ in. MRR = 7.3 in^3/min

Figure 7

LINEAR LEAST SQUARES - REGRESSION ANALYSIS

MULTI-COAT Finishing Grade Inserts	Insert Geom.	Size Style	Sp @ T_L = 10min. (Sfpm)	Chips & RMS (μ in.)	MRR @ T_L = 10min. (in^3/min)	log Sp vs log T_L Slope
Single Point Turning: DOC = 0.060 inches	TNMM	432	542	F - 125	4.7	-0.09
	SNMM	432	550	F - 125	4.8	-0.12
Fd = 0.012 ipr	CNMM	432	501	G - 125	4.3	-0.08
	DNMM	442	413	F - 125 +	3.6	-0.15
	TNMM	432	475	G - 125 +	5.8	-0.25
Fd = 0.017 ipr	SNMM	432	404	G - 125 +	4.9	-0.30
	CNMM	432	380	G - 125	4.7	-0.24
	DNMM	442	284	G - 125	3.5	-0.21
	TNMM	432	447	G - 125 +	6.4	-0.11
Fd = 0.020 ipr	SNMM	432	376	G - 125 +	5.4	-0.13
	CNMM	432	311	G - 125	4.5	-0.14

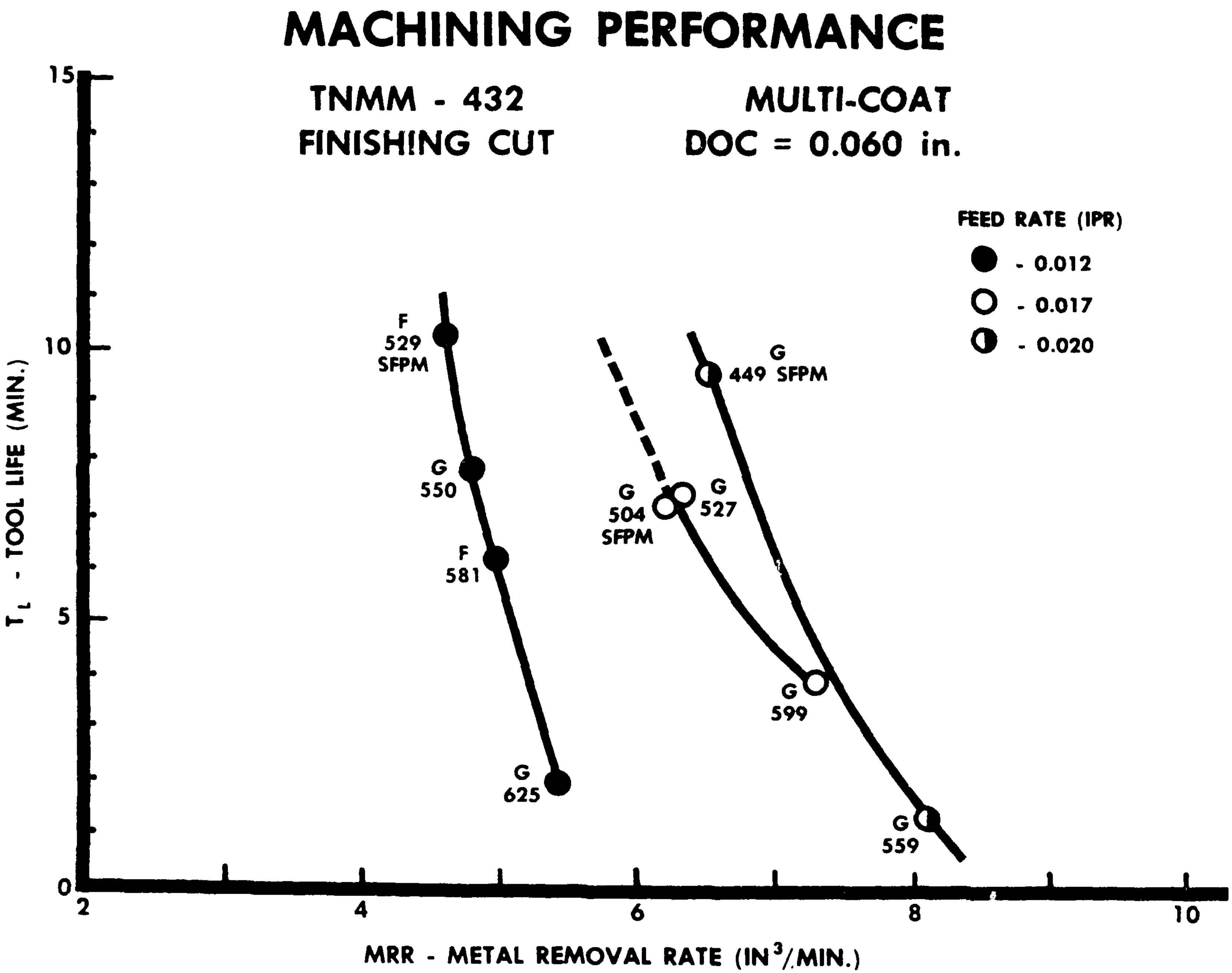

MACHINING PERFORMANCE
TNMM - 432
FINISHING CUT
MULTI-COAT
DOC = 0.060 in.
FEED RATE (IPR)
- 0.012
- 0.017
- 0.020
F
529
SFPM
G
550
F
581
G
625
G
504
SFPM
G
527
G
449 SFPM
G
599
G
559
15
10
5
0
2
4
6
8
10
T_L - TOOL LIFE (MIN.)
MRR - METAL REMOVAL RATE (IN^3/MIN.)

FIGURE 8

OBSERVATIONS

MULTI-COAT

Finishing Grade Inserts

Single Point Turning:

Workpiece: 4140 Steel
H.R. Tubing

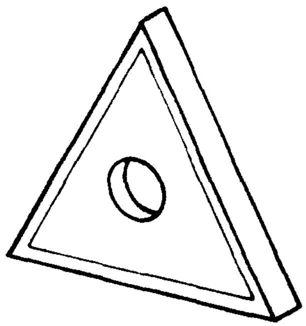
Hardness: HRC = 32

CUTTING CONDITION:

Dry, Cool Workpiece

WEAR LIMIT: 0.010 in.
Flank

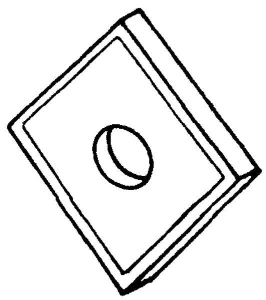
Feed = 0.017 ipr
DOC = 0.060 inches



TNMM 432

Sp = 475 sfpm

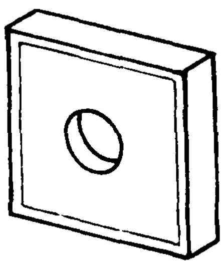
@ T_L = 10 min.



CNMM 432

Sp = 380 sfpm

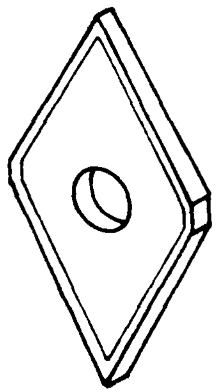
@ T_L = 10 min.



SNMM 432

Sp = 406 sfpm

@ T_L = 10 min.



DNMM 442

Sp = 284 sfpm

@ T_L = 10 min.

FIGURE 9

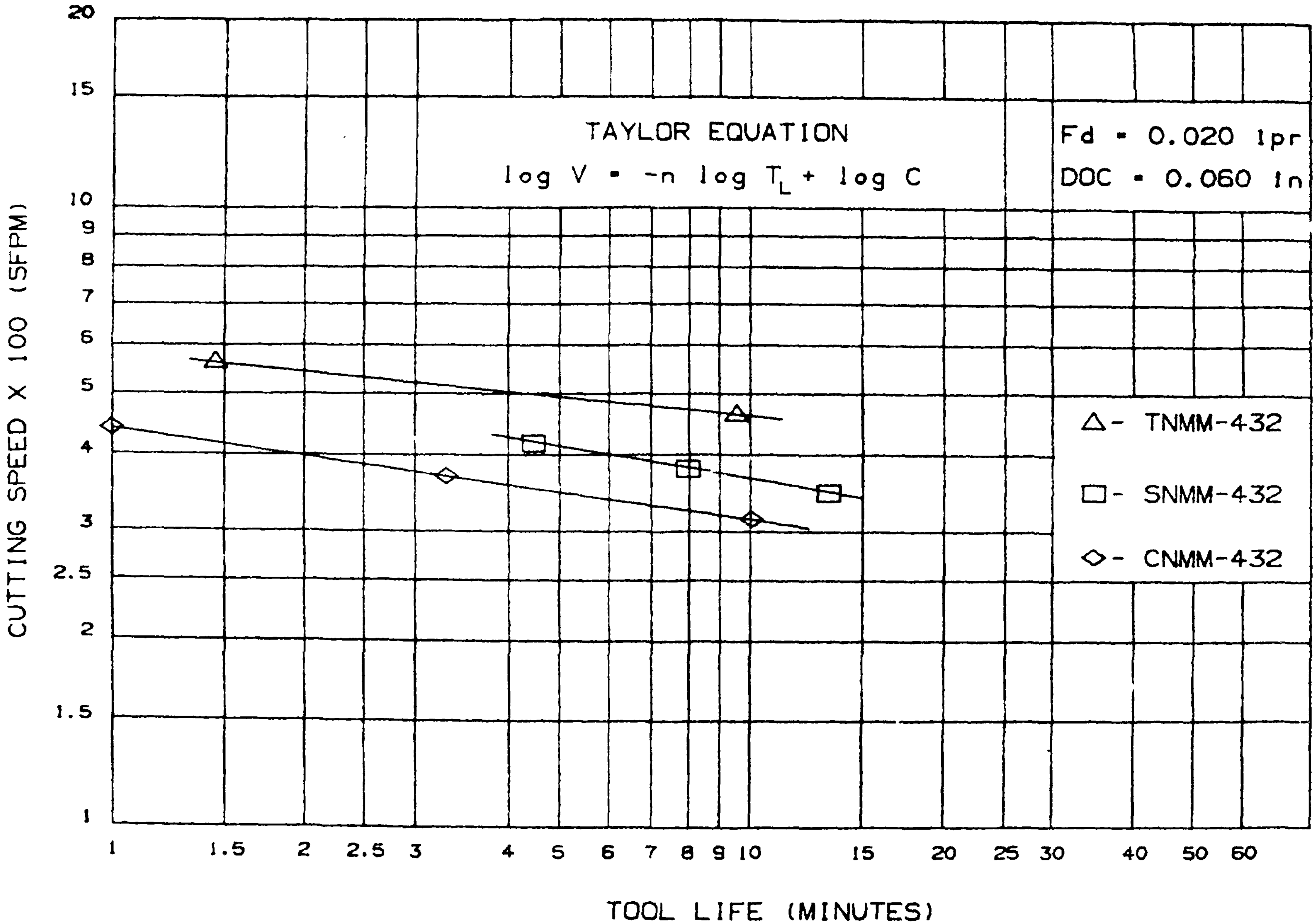

TAYLOR EQUATION
log V = -n log T_L + log C
Fd = 0.020 ipr
DOC = 0.060 in
△- TNMM-432
□- SNMM-432
◇- CNMM-432
CUTTING SPEED X 100 (SFPM)
TOOL LIFE (MINUTES)
20
15
10
9
8
7
6
5
4
3
2.5
2
1.5
1
1
1.5
2
2.5
3
4
5
6
7
8
9
10
15
20
25
30
40
50
60

FIGURE 10

rates and surface finish of the workpiece when cutting with various sizes and shapes of inserts. Clearly, the results (Figures 8 and 10) demonstrate that as cutting speeds, and proportionately cutting temperatures, increase at a given feed rate, tool life will decrease regardless of the insert size or shape. This is also true regardless of coating, grade, or substrate. For any insert shape, as feed rate and MRR increases, the speed (V_{10}) allowing a tool life of 10 minutes will correspondingly decrease. The influence of insert shape on V_{10} (see Table 2) was the same as the order of geometric strengths described in section 2.2. Rounds can withstand higher speeds than squares or triangles, which in turn can out-perform either of the two diamond shapes. These observations were valid for the AL_2O_3-and multi-coated insert grades and for both finishing and roughing sizes (see Appendices C and D, respectively). Depending upon substrate class, coating, shape and style, there was a significant difference of V_{10} among some vendors for the tested tools.

For corresponding insert shapes, the average speeds (V_{10}) at T_L=10 minutes differed by very little between the two coating types for finishing inserts. However, based on fewer test results for roughing size inserts, the multi-coated grades appeared to be slightly favored. To compare the performance of non-coated versus coated inserts, several shapes and carbide substrate classes were examined and documented in Appendices C and D. It was noted that in every case for both finishing and roughing sizes where style, shape, substrate, and feed rate were the same, the coated inserts could be run at significantly higher speeds (V_{10}).

Machining data computer program with two example runs are presented in Appendix E. First, 18 finishing size insert grades for the 80 degree diamond geometry were compared. Using the same given set of machining conditions, the computer program selected nine inserts, which satisfied the application specifications. Examination of the results for tools No. 310 (a multicoated grade) and No. 318 (a noncoated grade) of the same size and substrate class shows the distinct advantage of a coated insert. Insert No. 318 has a T_L of 5.0 min., and can be run at only 422 SFPM for a MRR of 5.2 in.^{3}/min. This means a cost of $0.23/in.^{3} while yielding a length of cut of 23 inches before a fresh cutting edge is needed. Whereas, insert No. 310 has a T_L of 11.7 min. running at 500 SFPM and removing 6.1 in.^{3}/min. at a cost of $0.18/in.^{3}. It produces a length of cut of 63 inches before a new cutting edge is required. A cost savings of 28 percent per in.^{3} of metal removed is shown, along with a substantial time savings by not having to index the insert while producing a greater length of cut. Similar comparisons are validated for roughing size inserts using the second example seen in Appendix E.

It is well known that as feed rate is increased workpiece surface roughness will increase. Also, as cutting tool wear progresses, surface quality and chip control tend to deteriorate. These patterns were both observed during the tests. Also in the tests, an increase in nose radius for most inserts enhanced the T_L at a given speed. The increased nose radius improved surface finishes at various feed rates, independent of shape, IC, size, and coating type. Therefore, it was not unexpected that round inserts

did produce the best surface finishes, frequently even when tested at higher feed rates than the other shapes. Also, round inserts showed the largest 10 minute tool life speeds (V_{10}).

Chip control was independent of coating type, but as expected, it was very dependent on feed rates. Results confirmed that increased feed rate increases the percentage of good or fair chips over poor chips, regardless of cutting speed, shape, or insert grade. In general, manufacturer technical data sheet recommendations for applying varied molded chip groove styles were validated within specified ranges of feeds and DOCs.

5.0 TECHNOLOGY TRANSFER

For effective transfer of the large quantities of technical data from this project to the Rock Island Arsenal Operations Directorate, various means were employed. Individual test results in the form of photo documentation were prepared, e.g., Figure 7. These displays represented in excess of 700 individual tests and provided rapid visual comparative assessment of results. The photos were arranged in order of ascending MRR according to insert grade, size, shape, and coating type. Tabulated data summaries (Appendices C and D) were distributed to Rock Island Arsenal Operations Factory and Process Engineering Divisions. Included were the Methods and Standards Branch, where inserts are selected and machining parameters are set; the N/C Programming Branch, where machine cutter paths are generated; and the N/C Toolsetting Branch, which is responsible for tool inventory control and carbide insert ordering.

To foster implementation of the established empirical data base, a user interactive tool selection computer program was prepared (Appendix E). Figures 11 and 12 outline the inputs and outputs for this sorting program. The program permits the entire data base to be accessed to aid the factory process personnel in selecting a specific insert best suited to a particular application and to establish operating parameters. Computer calculations of minimum costs and maximum production rates also can be requested. Information on insert stock number, availability, and optimum tool life are likewise provided for the user. The cutting tool data base program is written in Fortran 77, with versions for both Prime and DEC VAC systems. This information is available on 1/2 inch magnetic tape to DoD users.

To reach DoD users, some of whom have requested the data and data base program, an End of Project Presentation was held on November 6, 1986, and a paper was presented at MTAG '85 in Washington, DC.

A shop floor test data validation plan was developed and adapted to production requirements. The usage of 26 top performing finishing size inserts (as selected by Methods and Standards personnel) were tracked in several cost centers using numerical controlled machine tools for 12 months. At the end of that period it was noted that 65 percent of the insert grade-shape combinations had been called for and tried. Interviews with N/C programmers and machine operators verified the correctness of the established data base and its value in properly applying single point turning or boring tools

INPUTS FOR CUTTING TOOL SELECTION PROGRAM

● SHAPE OF INSERT	(TRIANGLE, SQUARE, ETC.)
● FINISH REQUIRED	(MICRO-INCHES RMS)
● CHIP QUALITY	(GOOD, FAIR, POOR)
● DEPTH OF CUT	(THOUSANDTHS OF AN INCH)
● FEED	(THOUSANDTHS OF AN INCH/REV)
- USER SPECIFIED	
- PROGRAM SEARCHES DATA FOR ALL FEEDS	
● TOOL LIFE	
- USER SPECIFIED	(MINUTES)
- LENGTH OF CUT	(INCHES)
- SURFACE SPEED	(FEET/MINUTE)
- MINIMUM COST - - (APPROX. BASED ON USER SUPPLIED DATA)	
● TIME TO CHANGE INSERT	(MINUTES)
● COST/EDGE	(DOLLARS)
● LABOR-OVERHEAD RATE	(DOLLARS/HOUR)
- MAXIMUM PRODUCTION	(CUBIC INCHES/MINUTE)

FIGURE 11

OUTPUTS OF CUTTING TOOL SELECTION PROGRAM

- INPUTS RESTATED
- IDENTIFICATION OF SELECTED INSERTS
  - TOOL OR INVENTORY NUMBER
  - VENDOR
  - GRADE (COATING)
  - GEOMETRY & SIZE CODE
- SPEEDS
  - SURFACE (FEET/MINUTE)
  - ROTATION (REVOLUTIONS/MINUTE)
- METAL REMOVAL RATE (CUBIC INCHES/MINUTE)
  - BASED ON CLOSEST EMPIRICAL DATA
  - COMPUTED FROM SPECIFIED DEPTH & FEED
- LENGTH OF CUT OR TOOL LIFE (IF NOT SPECIFIED BY USER)
- COST -- FOR OPTIMUM TOOL LIFE (DOLLARS/CUBIC-INCH)

FIGURE 12

As a consequence of this project, several follow-on test programs for machining were initiated at Rock Island Arsenal. Turning tests have continued using next generation coated carbides and allowing for performance comparisons with TiC/TiN coated inserts. Plans have been made to test coolants and the newest ceramic and cermet tool materials.

In-production testing of rotary cutting tools has been underway under another project for more than a year, as test results are being used for cost effectiveness comparisons and analyses and the selection of upgraded tooling. Algorithms were developed which quantify information needed for objective comparison of different vendor's tools and for tool edge preparations. Automatic recording of measured operational data enables calculations of productivity, cost, and horsepower per rate of metal removed as well as trend identification with wear and regrinding. Consequently, certain critical stages during a tools's life cycle can be monitored and necessary corrective actions adopted, e.g., if reconditioning steps are required or if the tool needs to be replaced. Selective reduction in tool inventory should result, along with increased productivity and improved part quality.

The project in this report developed reliable data on tool life and process parameters, largely for production planning and inventory control purposes, although it can be used to guide the lathe or turning center operator as to when the tool should be changed. The second project mentioned in this report, which provides automatic recording of measured operational data, goes a step beyond, since it allows operators of special machining centers to see the effect of tool wear on these operational data. However, with the advent of cells, the situation will occur where there will not be an operator assigned to each machine tool to monitor just the machining on that machine tool. In that case, the data base developed in this project is invaluable for accurate prediction of cycle times and schedules and for proper tool management, which will not only make certain a fresh tool is available, but also will minimize tool failure and cutting with worn tools. Nevertheless, the task of empirical investigation of tool life for all combinations of feeds, speeds, and workpiece materials would be prohibitive. Therefore, a third effort is underway to develop at least one automatic integrated sensing system capable of accepting data on part dimensions and surface finish, direct measurement of tool wear and cutting forces, and, accordingly, exercising limited control over the machining. Not only could this system provide protection in situations where reliable and extensive testing had not been performed, but it could also perform the monitoring functions that would be normally conducted by an operator if an operator were assigned to the machine tool.

Finally, it is envisioned that data from all these systems will be inputs to a custom tool management system that will ensure high percentages of machine cutting time, high metal removal rates, acceptable parts including first parts in a flexible automated environment as well as an attended one, providing cost effective machining and low tooling costs.

6.0 SUMMARY

A reliable, empirically derived tool wear life data base for both finishing and roughing sizes of coated carbide inserts was created. A menu driven user interactive computer program was developed which facilitated technology transfer. This program provided the means to sort, rank, and select insert grades and to obtain recommended machining parameters applicable to medium alloy steels for turning and boring. A shop floor test data verification study was carried out proving to be adaptable to production requirements. Algorithms were developed permitting quantitative comparisons among different manufacturer's tools. Benefits have been derived from more universal application of coated carbides, and selective reduction in tool inventory, setting of optimum machining parameters, and improved part quality as this program has fostered the extended and accelerated application of new and upgraded tooling at Rock Island Arsenal. A follow-on testing program was implemented, which is applicable for next generation coated carbides, coolants, ceramic tool materials, and other projects for rotary tools and for machine tool monitoring are supplementing or building upon the reported effort.

This page intentionally left blank.

BIBLIOGRAPHY

Cutting Tool Materials and Applications, Clinic Proceedings, March 3-5, 1987, Society of Manufacturing Engineers, Dearborn, Michigan.

Datsko, J. and Kirschbaum, R.A., Automated Process Control for Machining (CAM), EN-86-05, Engineering Directorate, Rock Island Arsenal, Illinois, July 1986.

Dearnley, P.A., "Rake and Flank Wear Mechanisms of Coated and Uncoated Cemented Carbides," Trans. of the ASME, Volume 107, page 68, January 1985.

Dearnley, P.A. and Trent, E.M., "Wear Mechanisms of Coated Carbide Tools," Metals Technology, Volume 9, page 60, February 1982.

Doyle, L.E., et. al., "Economics of Metal Cutting," Chapter 17, Manufacturing Processes and Materials for Engineers, 2nd Edition, Prentice-Hall Inc., Englewood Cliff, NJ, 1969.

Gilbert, W.W., "Economics of Machining," Machining - Theory and Practice, American Society for Metals, Metals Park, Ohio, 1950.

Kane, George E., Editor, Modern Trends in Cutting Tools, 1st Edition, Society of Manufacturing Engineers, Dearborn, Michigan, 1982.

Komanduri, R. and Desai, J.D., "Tool Materials for Machining," Carbide and Tool Journal, Volume 15, number 4, page 3, September-October, 1983.

Prokosch, M.W., "What You Should Know About Today's Carbides," Modern Machine Shop, page 76, June 1983.

Schey, John A., Tribology in Metalworking, Friction, Lubrication and Wear, Chapter 11, American Society for Metals, Metals Park, Ohio, 1983.

Srinivas, B. K., "Tools for Turning," Cutting-Tool Selection, Section 5, pp. 65-74, American Machining Guidebook, September 1981.

Tipnis, V.A., Editor, Influence of Metallurgy on Machinability, American Society for Metals, Metals Park, OH, 1975.

Tool Life Testing with Single-Point Turning Tools, Modified/ISO 685-1977, ANSI/ASME B94.55M, 1985.

Trent, E.M., Metal Cutting, 2nd Edition, Butterworths, London, UK, 1984.

Turning Handbook of High Efficiency Metal Cutting, Carboloy Systems Department, General Electric Co., 1980.

Wertheim, R., et. al., "Characterization of CVD Coated Layers and Their Thermal Properties," Annals of the CIRP, Volume 31, Number 1, page 7, 1982.

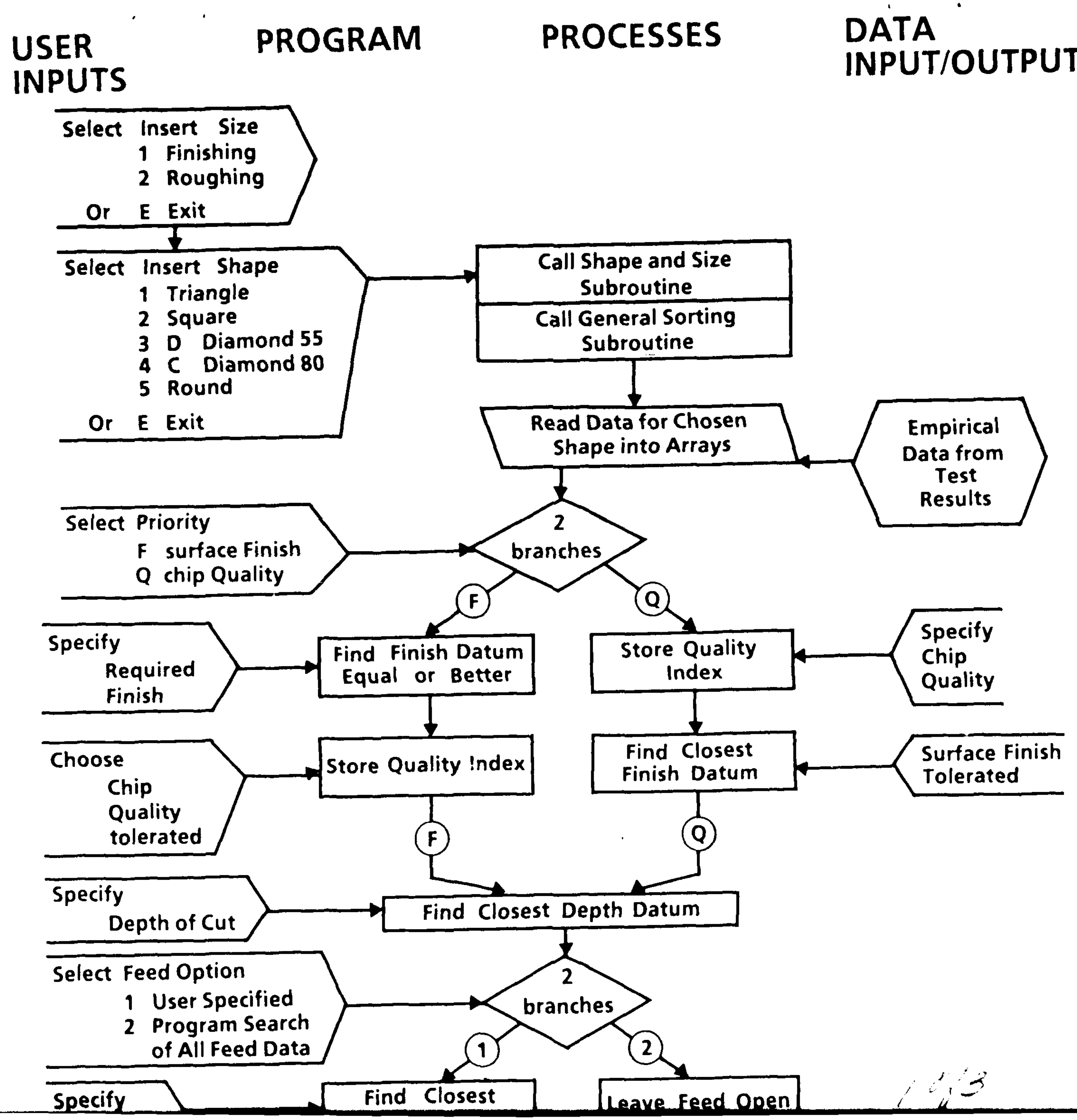
World Directory and Handbook of Hard Metals, 3rd Edition, Part I, Sections 3, 4, 9, pp. 17-42, International Carbide Data and Engineering Digest Ltd., Herts, UK, 1982.

This page intentionally left blank.

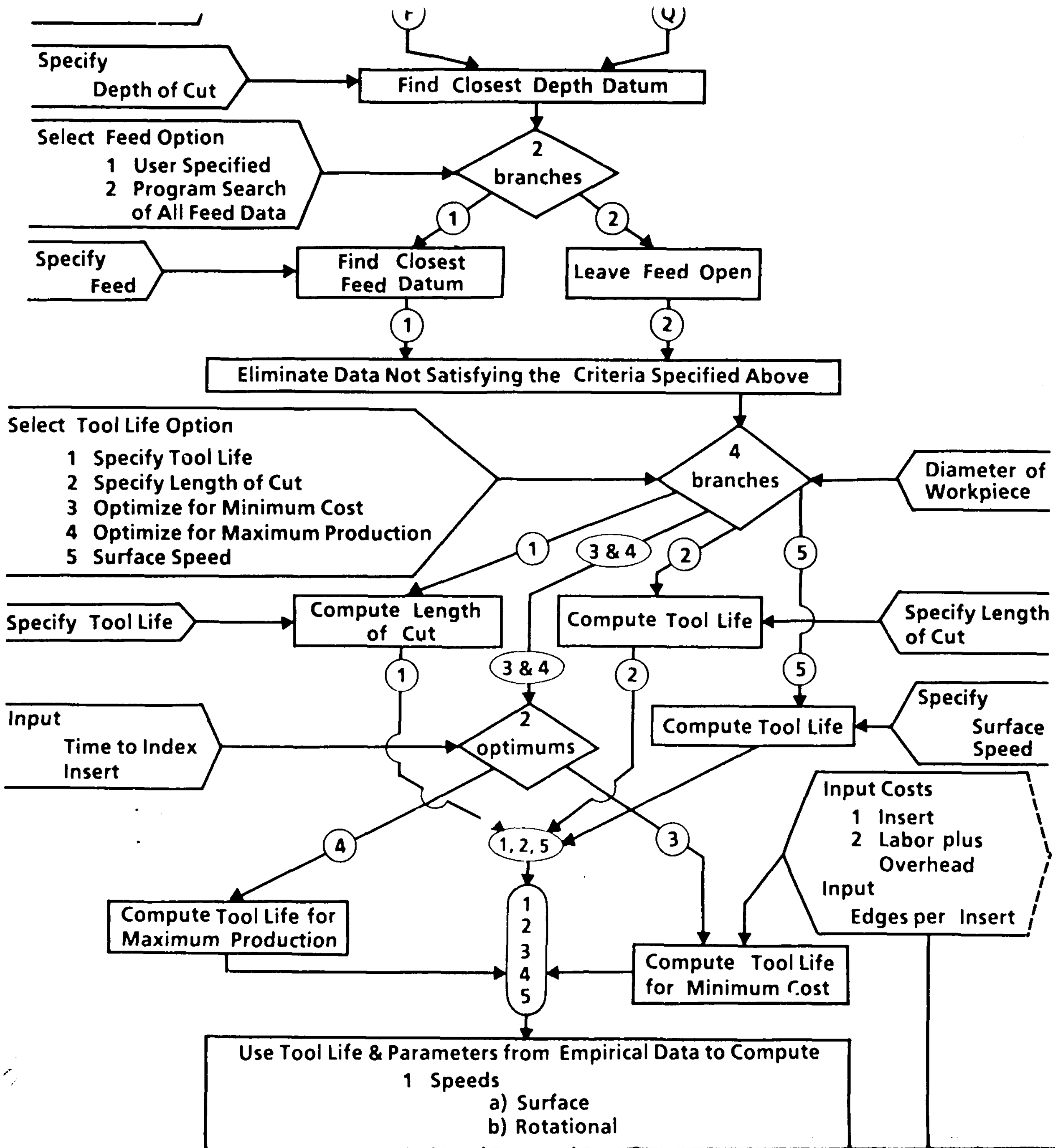
APPENDIX A

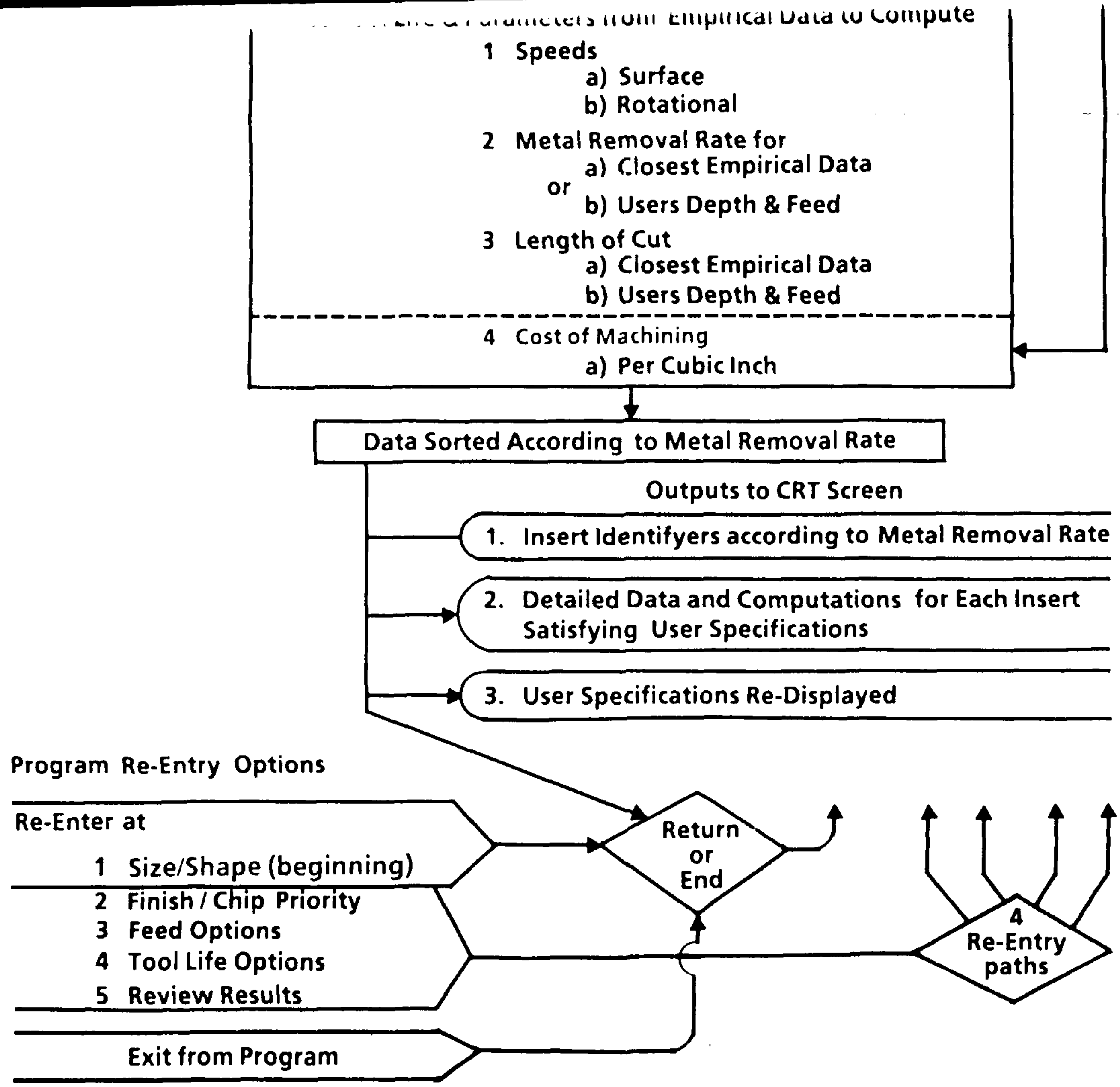
SORTING PROGRAM FLOWCHART

This page intentionally left blank.



USER INPUTS
PROGRAM
PROCESSES
DATA INPUT/OUTPUT
Select Insert Size
1 Finishing
2 Roughing
Or E Exit
Select Insert Shape
1 Triangle
2 Square
3 D Diamond 55
4 C Diamond 80
5 Round
Or E Exit
Call Shape and Size Subroutine
Call General Sorting Subroutine
Read Data for Chosen Shape into Arrays
Empirical Data from Test Results
Select Priority
F surface Finish
Q chip Quality
2 branches
F
Q
Specify Required Finish
Find Finish Datum Equal or Better
Store Quality Index
Specify Chip Quality
Choose Chip Quality tolerated
Store Quality Index
Find Closest Finish Datum
Surface Finish Tolerated
F
Q
Specify Depth of Cut
Find Closest Depth Datum
Select Feed Option
1 User Specified
2 Program Search of All Feed Data
2 branches
1
2
Specify
Find Closest
Leave Feed Open


Specify Depth of Cut
Find Closest Depth Datum
Select Feed Option
1 User Specified
2 Program Search of All Feed Data
2 branches
Specify Feed
Find Closest Feed Datum
Leave Feed Open
Eliminate Data Not Satisfying the Criteria Specified Above
Select Tool Life Option
1 Specify Tool Life
2 Specify Length of Cut
3 Optimize for Minimum Cost
4 Optimize for Maximum Production
5 Surface Speed
4 branches
Diameter of Workpiece
Specify Tool Life
Compute Length of Cut
Compute Tool Life
Specify Length of Cut
Input
Time to Index Insert
2 optimums
Compute Tool Life
Specify Surface Speed
Input Costs
1 Insert
2 Labor plus Overhead
Input
Edges per Insert
Compute Tool Life for Maximum Production
Compute Tool Life for Minimum Cost
Use Tool Life & Parameters from Empirical Data to Compute
1 Speeds
a) Surface
b) Rotational


... Life & Parameters from Empirical Data to Compute
1 Speeds
a) Surface
b) Rotational
2 Metal Removal Rate for
a) Closest Empirical Data
or
b) Users Depth & Feed
3 Length of Cut
a) Closest Empirical Data
b) Users Depth & Feed
4 Cost of Machining
a) Per Cubic Inch
Data Sorted According to Metal Removal Rate
Outputs to CRT Screen
1. Insert Identifyers according to Metal Removal Rate
2. Detailed Data and Computations for Each Insert Satisfying User Specifications
3. User Specifications Re-Displayed
Program Re-Entry Options
Re-Enter at
1 Size/Shape (beginning)
2 Finish / Chip Priority
3 Feed Options
4 Tool Life Options
5 Review Results
Exit from Program
Return or End
4 Re-Entry paths

3/13

APPENDIX B

SORTING PROGRAM LISTING, INCLUDING THE DATA FILES

This page intentionally left blank.

```
      PROGRAM TOOL06
C************** FILE NAME ********************** TOOL *************************
C
C=============================================================================
C
C   COMPUTER SYSTEM      : PRIME
C
C   COMPUTER LANGUAGE    : FORTRAN 77
C
C   SYSTEMS DESIGNER     : BILL BREWER, MARY CROSHECK
C
C   VERSION/DATE         : 6 / 01-JUL-1986
C
C=============================================================================
C
C   PURPOSE              : SORTS THE TEST DATA COLLECTED ON CUTTING INSERTS
C                          ACCORDING TO CHIP QUALITY AND SURFACE FINISH
C                          SELECTS FEEDS
C                          COMPUTES SPEEDS, METAL REMOVAL RATE, LENGTH OF CUT,
C                          AND COST
C
C   SUBROUTINE CALLED    :   1. GEN_SORT
C                            2. F_TRIANGLE             7. R_TRIANGLE
C                            3. F_SQUARE               8. R_SQUARE
C                            4. F_C_DIAMOND_80         9. R_C_DIAMOND_80
C                            5. F_D_DIAMOND_55        10. R_D_DIAMOND_55
C                            6. F_ROUND               11. R_ROUND
C
C=============================================================================
C
C    INPUTS
C             1    Size of Insert                   ( finishing or roughing )
C             2    Shape of Insert                  ( triangle, square, etc. )
C             3    Finish Required                  ( micro-inches RMS )
C             4    Chip Quality                     ( good, fair, poor )
C             5    Depth of Cut                     ( thousandths of an inch )
C             6    Feed                             (      "        "  "   "  )
C                    a)   User specified
C                    b)   Program searchs data for ALL Feeds
C             7    Tool Life
C                    a)   User specified            ( minutes )
C                    b)   Length of Cut             ( inches  )
C                    c)   Surface Speed             ( feet / min. )
C                    d)   Minimun Cost -- approx. based on user supplied data
C                          i)    time to change insert ( minutes )
C                         ii)    cost / edge           ( dollars )
C                        iii)    labor + overhead rate ( dollars / hour )
C                    e)   Maximum Production
C
C -----------------------------------------------------------------------------
C
C    OUTPUTS
C             1    Inputs  Restated
C             2    Identification of Selected Inserts
C                    a)   Tool or inventory number
```

```
C                   b)    Vendor
C                   c)    Grade                        ( coating )
C                   d)    Geometry & Size code
C             3   Speeds
C                   a)    Surface                      ( feet / minute )
C                   b)    Rotation                     ( revolutions / minute )
C             4   Metal Removal Rate                   ( cubic inches/ minute )
C                   a)    Based on closest empirical data
C                   b)    Computed from specified depth & feed
C             5   Length of Cut   or   Tool Life      ( if not specified by user )
C             6   Cost -- for optimum tool life        ( dollars / cubic-inch )
C
C   FILES USED
C
C    FILE NAME          EMPIRICAL DATA FOR                         TYPE    I/O
C    ---------          ------------------                         ----    ---
C    F_TRIDATA          TRIANGULAR INSERTS IN FINISHING            DISK     I
C    F_SQUDATA          SQUARE INSERTS IN FINISHING                DISK     I
C    F_DIA80DATA        80 DEG DIAMOND INSERTS IN FINISHING        DISK     I
C    F_DIA55DATA        55 DEG DIAMOND INSERTS IN FINISHING        DISK     I
C    F_ROUDATA          ROUND INSERTS IN FINISHING                 DISK     I
C    R_TRIDATA          TRIANGULAR INSERTS IN ROUGHING             DISK     I
C    R_SQUDATA          SQUARE INSERTS IN ROUGHING                 DISK     I
C    R_DIA80DATA        80 DEG DIAMOND INSERTS IN ROUGHING         DISK     I
C    R_DIA55DATA        55 DEG DIAMOND INSERTS IN ROUGHING         DISK     I
C    R_ROUDATA          ROUND INSERTS IN ROUGHING                  DISK     I
C
C=========================================================================
C
C                          PROGRAM LOGIC SYNOPSIS
C
C   1.
C          USER SELECTS THE SIZE AND GEOMETRY OF CUTTING TOOL
C          OPEN APPROPRIATE DATA FILE
C
C   2.
C          USER CHOOSE PRIORITY OF SORTING ( CHIP QUALITY/ SURFACE FINISH )
C          USER INPUTS PARAMETERS OF CUTTING CONDITIONS
C                    ( DEPTH OF CUT, FEED, TOOL LIFE )
C
C          USER HAS OPTION TO SPECIFY FEED OR TO LEAVE THE FEED OPEN
C                    ( SORT THROUGH ALL FEEDS )
C
C          USER HAS OPTION TO SPECIFY TOOL LIFE IN TERMS OF MINUTES,
C               LENGTH OF CUT, SURFACE SPEED, MINIMUM COST,
C               OR MAXIMUM PRODUCTION
C               ( LAST FOUR OPTIONS ARE CONVERTED TO MINUTES )
C
C   3.
C          FOR ALL INSERTS WHICH PASS THE CHIP QUALITY AND SURFACE
C             FINISH REQUIREMENTS, A SPEED FOR THE PARAMETERS CHOSEN
C             IS CALCULATED AND ALL INPUT/OUTPUT DATA IS SHOWN TO USER.
C
C   4.
C          USER MAY RE-ENTER PROGRAM AT 4 POINTS:
```

```
C            *  RETURN TO BEGINNING OF PROGRAM
C            *  SURFACE FINISH/ CHIP QUALITY OPTIONS
C            *  FEED OPTIONS
C            *  TOOL LIFE OPTIONS
C
C   5.
C          CLOSE APPROPRIATE DATA FILE
C          EXIT PROGRAM
C
C=======================================================================
C
C      NAME          DEFINITION                                        TYPE
C      ----          ----------                                        ----
C      DEPTH     ARRAY OF ALL POSSIBLE DEPTHS TESTED                   REAL
C      SPEED     ARRAY OF SPEEDS BASED ON TOOL LIFE FOR INSERTS        REAL
C      FEED      ARRAY OF ALL POSSIBLE FEEDS TESTED                    REAL
C      TOLIFE    ARRAY OF TOOL LIFE (IN MIN.) FOR INSERTS TESTED       REAL
C      RMRR      ARRAY OF METAL REMOVAL RATE FOR INSERTS               REAL
C      UMRR      ARRAY OF M. R. R. BASED ON USER INPUTTED VALUES       REAL
C      RPM       ARRAY OF SPEEDS (IN RPM) FOR INSERTS                  REAL
C      ULOC      ARRAY OF LENGTH OF CUT FOR USER INPUTTED VALUES       REAL
C      LOC       ARRAY OF LENGTH OF CUT FOR TEST PARAMETERS            REAL
C      ASERT     ARRAY OF INSERT DESCRIPTIONS                          A79
C      ANOTE     ARRAY OF CAUTIONS FOR THE INSERTS                     A79
C      ACHIP     ARRAY OF POSSIBLE CHIP QUALITY CHOICES                A50
C      SFINISHCH ARRAY OF OUTPUTTED SURFACE FINISHES                   A10
C      KSERT     ARRAY OF INSERT INDEXES TO KEEP AFTER SORT            INT
C      KDEPTH    ARRAY OF DEPTH OF CUT INDEXES AFTER SORT              INT
C      KFEED     ARRAY OF FEED INDEXES TO KEEP AFTER SORT              INT
C      MAX       ARRAY OF INSERT INDEXES SORTED BY MAXIMUM M.R.R.      INT
C      SFINISH   ARRAY OF ALL SURFACE FINISHES TESTED                  INT
C      IFINISH   ARRAY OF SURFACE FINISH INDEX FOR INSERTS             INT
C      ICHIP     ARRAY OF CHIP QUALITY INDEX FOR INSERTS               INT
C      TL_1MIN   ARRAY OF 1 MIN. LOG INTERCEPT FOR INSERTS             INT
C      TL_PWR    ARRAY OF SLOPES OF LOG-PLOT FOR INSERTS               INT
C-----------------------------------------------------------------------
C      MSERTS    MAXIMUM NUMBER OF INSERTS POSSIBLE FOR ANY GEOM.      INT
C      NSERTS    NUMBER OF INSERTS FOR THE PARTICULAR GEOMETRY         INT
C      MDEPTHS   MAXIMUM NUMBER OF DEPTHS POSSIBLE FOR ANY GEOM.       INT
C      NDEPTHS   NUMBER OF DEPTHS FOR THE PARTICULAR GEOMETRY          INT
C      MFEEDS    MAXIMUM NUMBER OF FEEDS POSSIBLE FOR ANY GEOM.        INT
C      NFEEDS    NUMBER OF FEEDS FOR THE PARTICULAR GEOMETRY           INT
C      MFINISHS  MAXIMUM NUMBER OF FINISHES POSSIBLE FOR ANY GEOM.     INT
C      NFINISHS  NUMBER OF FINISHES FOR THE PARTICULAR GEOMETRY        INT
C      MCHIPS    MAXIMUM NUMBER OF CHIP POSSIBLILITIES FOR ANY GEOM.   INT
C      NCHIPS    NUMBER OF CHIP POSSIBILITIES FOR PARTICULAR GEOM.     INT
C      MKEEPERS  MAXIMUM NUMBER OF INSERT/FEED COMBINATIONS POSS.      INT
C      KEEPER    NUMBER OF INSERT/FEED COMBINATIONS KEPT               INT
C      MUNIT     UNIT FILE NUMBER FOR APPROPRIATE GEOM. DATA FILE      INT
C      DFILE     UNIT FILE NAME FOR APPROPRIATE GEOMETRIC DATA FILE    A10
C      GEOM_NAME GEOMETRIC NAME FOR INSERTS USED IN FORMATS            A15
C
C***********************************************************************
C
C
```

```
C
      CHARACTER ASHAPE
      CHARACTER ARUN
      CHARACTER APAGE
      CHARACTER ASIZE

      WRITE ( 1, 10 )
10    FORMAT (///////,27X,'MACHINING DATA PROGRAM',///,37X,'FOR',//,
     &  27X,'FINISHING / ROUGHING  SIZE',//,25X,'COATED CARBIDE ',
     &  'CUTTING INSERTS',//,35X,'USED IN',//,30X,'TURNING OPERATIONS',
     &        //////,26X,'HIT <RETURN> TO CONTINUE')
      READ ( 1,'(A1)' )  APAGE
      WRITE( 1, 20 )
20    FORMAT( /////,30X,'EXPERIMENTAL',/,30X,'------------',//,
     &         'EQUIPMENT    --  Single point turning using a 30/60 ',
     &                        'horsepower turret lathe',//,
     &         'CUTTING CONDITION --  Dry cutting only with fluid ',
     &                        'cooled workpiece',//,
     &        'WORKPIECE MATERIAL--  AISI 4140 steel, hot rolled tubing ',
     &        'for finishing inserts.',/,22X,'Heat treated, Quenched ',
     &        'and Tempered to HRC 31 - 33',/,16X,'AISI 4140 ',
     &        '& 4130 steel, hot rolled tubing for roughing inserts.',
     &        /,16X,'Heat treated, Quenched and Tempered to HRC 31 - 34',
     &        //,'TOOL MATERIALS --  CVD coated carbide inserts',/,19x,
     &        'ALOX   : ALOX exterior coating with TiC coat at ',
     &        'substrate ',/,27X,'interface',/,19x,
     &        'Multi : TiN exterior coating with ALOX coat inter',
     &        'mediate, ',/,26X,
     &        'and TiC or TaC coat at substrate interface',//,
     &        'TOOL HOLDERS  --  Negative 5 degree back rake and side ',
     &        'rake angles with SCEA ',/,18X,
     &        'ranging from + 15 degrees to -3 degrees depending on ',/,
     &        18X,'shape of insert ',//,26X,'ENTER <RETURN> TO CONTINUE')
      READ( 1, '(A1)' ) APAGE
      WRITE( 1, 30 )
30    FORMAT( //,'TOOL INSERT SIZE --  IC = 1/2 in. for finishing ',
     &                    'cut, DOC = 0.060 in.',/,
     &               21X,'IC = 5/8 in. or 3/4 in. for roughing cut, ',
     &                     'DOC = 0.200 in.',//,
     &                'TOOL WEAR CRITERIA --  Finishing flank wear limits',
     &                  ' - 0.010" ave, or 0.020" max.',/,
     &               23X,'Roughing flank wear limits  - 0.015" ave, ',
     &                     'or 0.030" max. ',//,
     &                'MEASURING PROCEDURE --  Tool flank wear was ',
     &                  'measured at predetermined time',/,25X,
     &                  'intervals (min.) until wear limit was reached',
     &           ///,'PERFORMANCE --  Tool life (min.) was recorded ',
     &                   'when the flank wear limit was',/,17X,
     &                   'reached, and the quality of chip control/',
     &                   'form were judged and',/,17X,
     &                   'given a good, fair, or poor rating.',//,16X,
     &                   'Workpiece surface finishes were assigned ',
     &                   'RMS(micro-inch) values',/,17X,
     &                   'by visual/tactual comparisons using a Std. ',
     &                   'Ordnance Finishes',/,17X,
```

```
     &                     'Set No. 10.',//,16X,
     &                     'Wear mode patterns and occurance frequency ',
     &                     'were recorded per',/,17X,
     &                     'insert, as was the calculation of metal ',
     &                     'removal rate.',//,26X,
     &                     'ENTER <RETURN> TO CONTINUE' )
      READ( 1, '(A1)' ) APAGE
 40   WRITE ( 1, 35 )
 35   FORMAT(////////////,10X,'Select Size of Insert to be Used:',
     &       //,T30,'1   Finishing    (IC = 1/2 in.)',/,
     &       T30,'2   Roughing     (IC = 5/8 in. OR 3/4 in.)',//,
     &       T30,'E   Exit from the Program',////)
      READ ( 1, '(A1)' )  ASIZE
      IF ( ASIZE.EQ.'E' .OR. ASIZE.EQ.'e' )  GOTO 999
      IF ( ASIZE .NE. '1' .AND.
     &     ASIZE .NE. '2' .AND.
     &     ASIZE .NE. 'E' .AND.
     &     ASIZE .NE. 'e' )  THEN
        WRITE ( 1, 70 )
 70     FORMAT(//,10X,'Only Numbers 1 or 2 or the letter E',
     &                ' can be read as answers.')
        GOTO  40
      ELSE
      ENDIF
 45   WRITE ( 1,50 )
 50   FORMAT( /////////,10X,'Select Insert Shape',///,
     & T30,'1  triangular',/,
     & T30,'2  square',/,
     & T30,'3  diamond 80 degree',/,
     & T30,'4  diamond 55 degree',/,
     & T30,'5  round',//,
     & T30,'E  Exit from the program.',////)
C
C  For Response 2
C
      READ ( 1,'(A1)' ) ASHAPE
      IF( ASHAPE.EQ.'1'.AND.ASIZE.EQ.'1' ) CALL  F_TRIANGLE
      IF( ASHAPE.EQ.'2'.AND.ASIZE.EQ.'1' ) CALL  F_SQUARE
      IF( ASHAPE.EQ.'3'.AND.ASIZE.EQ.'1' ) CALL  F_C_DIAMOND_80
      IF( ASHAPE.EQ.'4'.AND.ASIZE.EQ.'1' ) CALL  F_D_DIAMOND_55
      IF( ASHAPE.EQ.'5'.AND.ASIZE.EQ.'1' ) CALL  F_ROUND
C
      IF( ASHAPE.EQ.'1'.AND.ASIZE.EQ.'2' ) CALL  R_TRIANGLE
      IF( ASHAPE.EQ.'2'.AND.ASIZE.EQ.'2' ) CALL  R_SQUARE
      IF( ASHAPE.EQ.'3'.AND.ASIZE.EQ.'2' ) CALL  R_C_DIAMOND_80
      IF( ASHAPE.EQ.'4'.AND.ASIZE.EQ.'2' ) CALL  R_D_DIAMOND_55
      IF( ASHAPE.EQ.'5'.AND.ASIZE.EQ.'2' ) CALL  R_ROUND
C
      IF( ASHAPE.EQ.'E'.OR.ASHAPE.EQ.'e' ) GOTO 999
C
C  Escape for Response 2
c
      IF( ASHAPE.NE.'1' .AND.
     &    ASHAPE.NE.'2' .AND.
     &    ASHAPE.NE.'3' .AND.
```

```
     &    ASHAPE.NE.'4' .AND.
     &    ASHAPE.NE.'5' .AND.
     &    ASHAPE.NE.'E' .AND.
     &    ASHAPE.NE.'e' ) THEN
      WRITE( 1,60 )
 60   FORMAT(//,10X,'Only numbers 1 to 5 or the letter E can be ',
     &               'read as answers.',//,
     &           10x,'Give it another try.')
      GOTO  45
      ELSE
      ENDIF
C
  999 CALL EXIT

      END


      SUBROUTINE GEN_SORT( MUNIT, DFILE, GEOM_NAME )
C
C  Array Dimension Parameters
C
      PARAMETER(MSERTS=25,MDEPTHS=1,MFEEDS=4,MFINISHS=6,MCHIPS=3
     &,MFINCH=6,MKEEPERS=MSERTS*MDEPTHS*MFEEDS,PI=3.14159)
C
C
C  Dimension ARRAYs
      REAL DEPTH( MDEPTHS ),FEED( MFEEDS )
      REAL SPEED( MKEEPERS ),TOLIFE( MKEEPERS )
      REAL RMRR( MKEEPERS ),UMRR( MKEEPERS )
      REAL TMRR( MKEEPERS )
      REAL COST( MKEEPERS )
      REAL RPM( MKEEPERS ), ULOC( MKEEPERS ), LOC( MKEEPERS )
      REAL SFPM, LOCUT, DOW, TOOLIFE
      REAL TCI, CPE, RLO
      CHARACTER*80 ASERT( MSERTS )
      CHARACTER*80 ANOTE( MSERTS )
      CHARACTER*50 ACHIP( MCHIPS )
      CHARACTER*10 SFINISHCH( MFINCH )
      INTEGER TOOLNO, TOOLOPT
      INTEGER TOLOPT
      INTEGER KSERT( MKEEPERS )
      INTEGER KDEPTH( MKEEPERS )
      INTEGER KFEED( MKEEPERS )
      INTEGER MAX( MKEEPERS )
      INTEGER SFINISH( MFINISHS )
      INTEGER IFINISH( MSERTS, MDEPTHS, MFEEDS )
      INTEGER   ICHIP( MSERTS, MDEPTHS, MFEEDS )
      REAL    TL_MIN( MSERTS, MDEPTHS, MFEEDS )
      REAL    TL_PWR( MSERTS, MDEPTHS, MFEEDS )
C
      CHARACTER*1 PRIORITY, DEPOPT, FEDOPT
      CHARACTER*1 APAGE, COSTOPT, ACONT
      CHARACTER*15 GEOM_NAME
```

```
      CHARACTER*11 DFILE
C
C
C  ***** Read DATA from file
C
      OPEN( MUNIT, FILE = DFILE )
C
C  ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 10 I = 1,11
 10   READ( MUNIT,'(I1)' )
C
C               * * * * * * * * * * * * * *
C  Read parametric variations used in tests
C
C   Read Data Parameters to be used for the particular
C   geometric Data file being read from.
C               * * * * * * * * * * * * * * *
C
      READ( MUNIT,* )  NSERTS, NDEPTHS, NFEEDS, NFINISHS, NCHIPS
      NFINCH = NFINISHS
C
      IF ( NSERTS .EQ. 0 )  THEN
         WRITE ( 1, 15 )
 15      FORMAT(////////////,10X,'THERE WERE NO INSERTS TESTED IN',
     &               ' THAT GEOMETRY AT THIS TIME..',//,
     &             20X,'PLEASE TRY ANOTHER GEOMETRY.',/////,
     &             20X,'ENTER ANY KEY TO CONTINUE',//)
         READ( 1, '(A1)' ) APAGE
         GOTO 9999
      ELSE
      ENDIF
C
C  ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 20  I = 1,3
 20   READ( MUNIT,'(I1)' )
C
C             * * * * * * * * * * * * * * * *
C  Read DEPTHs of cut tested  ( thousandths of an inch )
C  NOTE:  numbers must be entered in the DATA file from the
C         smallest INCREASING to the largest.
C             * * * * * * * * * * * * * * * *
C
      READ( MUNIT,* ) (  DEPTH( IDEPTH ), IDEPTH = 1,NDEPTHS )
C
C  ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 30 I = 1,3
 30   READ( MUNIT,'(I1)' )
C
C               * * * * * * * * * * * * * * * *
C  Read FEED variations  ( thousandths of an inch )
C  NOTE:  numbers must be entered in the DATA file from the
C         smallest INCREASING to the largest.
```

```
C                 * * * * * * * * * * * * * * * * *
C
      READ( MUNIT,* ) (  FEED( IFEED ), IFEED = 1,NFEEDS  )
C
C  ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 40 I = 1,3
 40   READ( MUNIT,'(I1)' )
C
C                 * * * * * * * * * * * * * * * * *
C  Read surface FINISHs obtained from tests  ( micro-inchs )
C  NOTE:  numbers must be entered in the DATA file from the
C         smallest INCREASING to the largest.
C                 * * * * * * * * * * * * * * * * *
C
      READ( MUNIT,* ) (  SFINISH( JFINISH ), JFINISH = 1,NFINISHS  )
C
C  ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 50  I = 1,7
 50   READ( MUNIT, '(I1)' )
C
C               * * * * * * * * * * * * * * * * * *
C   Read surface FINISHS for output later in program
C   NOTE:  Finishes must be entered in the DATA file from the
C          smallest INCREASING to the largest.
C               * * * * * * * * * * * * * * * * * *
C
      DO 60  I = 1, NFINISHS
 60   READ( MUNIT,'(10X,A10)' )  SFINISHCH(I)
C
C   *****  Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 70 I = 1,3
 70   READ( MUNIT,'(I1)' )
C
C                 * * * * * * * * * * * * * * * * *
C  Read CHIP qualities obtained from tests
C  NOTE:  descriptions of CHIPS must be entered in the DATA file from the
C         BEST proceeding to the WORST.
C                 * * * * * * * * * * * * * * * * *
C
      READ( MUNIT,'(A50)' ) (  ACHIP( JCHIP ), JCHIP = 1,NCHIPS  )
C
C  ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 80 I = 1,3
 80   READ( MUNIT,'(I1)' )
C
C
C  ******* Confirm choice of insert SHAPE
C
      WRITE( 1,'(/////////////////////////)' )
      WRITE( 1,90 ) NSERTS, GEOMNAME
 90   FORMAT( //,8X,'Program will search DATA for the ',
```

```
     &                  I2,'  ',A15,' inserts tested.',//)
C
C  ********  Read INSERT identification lines
C  ***********      (  2 lines of 79 spaces for each insert  )
C
      DO 100 INSERT = 1,NSERTS
            READ( MUNIT,'(A79)' ) ASERT( INSERT )
            READ( MUNIT,'(A79)' ) ANOTE( INSERT )
 100  CONTINUE
      K = 1
 110  DO 130 M = 1,NSERTS
            WRITE ( 1,'(A79)' ) ASERT( M )
            IF(  ( M - K*15 ) .GE.0  )  THEN
                 WRITE( 1,120 )
 120             FORMAT( /,25X,'Enter any key to continue .' )
                  K = K + 1
                 READ( 1,'(A1)' ) APAGE
            ENDIF
 130  CONTINUE
      WRITE ( 1,120 )
      READ ( 1,'(A1)' ) APAGE
C
C  ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 140 I = 1,40
 140  READ( MUNIT,'(I1)' )
C
C
C  *****  Read empirical RESULTS from tests into data ARRAYS
C
      DO 170 INSERT = 1,NSERTS
            READ( MUNIT,'(I1)' )
            DO 160 IDEPTH = 1,NDEPTHS
                 DO 150 IFEED = 1,NFEEDS
 150             READ( MUNIT,'(T31,2I10,2F10.4)' )
     &                      IFINISH( INSERT, IDEPTH, IFEED ),
     &                        ICHIP( INSERT, IDEPTH, IFEED ),
     &                      TL_MIN( INSERT, IDEPTH, IFEED ),
     &                      TL_PWR( INSERT, IDEPTH, IFEED )
 160        CONTINUE
 170  CONTINUE
C
C        * * * * * * * * * * * * *
C
C  Menu 2  -  Choice of PRIORITY
C
C        * * * * * * * * * * * * *
C
 180  WRITE( 1,190 )
 190  FORMAT( //////////,10X,'Choose FIRST Priority',///,
     &              T30,'F   surface Finish',//,
     &              T30,'Q      chip Quality',/////// )
C
C      * * * * * * * * * * * * *
C
```

```
C  Response 2  -  PRIORITY
C
C       * * * * * * * * * * * *
C
      READ( 1,'(A1)' ) PRIORITY
      IF( PRIORITY.EQ.'F'.OR.PRIORITY.EQ.'f' )  THEN
C
C    * * * * * * * * * * * * * * * *
C             Branch for 1st priority = surface Finish
C   Menu 3F  Ask for required surface Finish
C    * * * * * * * * * * * * * * * *
C
 200        WRITE( 1,210 )
 210        FORMAT( ////////////////////,10X,'Priority 1  -  surface ',
     &              'Finish',///,T20,'Type in surface Finish you must ',
     &              'have in',//,T30,'micro-inches RMS',/////// )
            READ( 1,*,ERR = 200 ) FINISH
C
C       * * * * * * * * * * * * * * * * * *
C  Find LARGEST finish number in data file LESS THAN or equal to that SPECIFIED.
C  NOTE:    numbers must be entered in the DATA file from the
C           smallest INCREASING to the largest.
C       * * * * * * * * * * * * * * * * * *
C
            KFINISH = 0
            DO 220 JFINISH = 1,NFINISHS
                IF( FINISH.GE.SFINISH( JFINISH ) ) KFINISH = JFINISH
 220        CONTINUE
            IF( KFINISH.EQ.0 ) KFINISH = 1
            WRITE( 1,230 ) FINISH, SFINISHEM( KFINISH ),
     &                     SFINISH( KFINISH )
 230        FORMAT( //////,20X,'You asked for a',F6.0,' micro-inch ',
     &       'finish.',//,20X,'Surface Finish data from test results',
     &       ' that',/,20X,' are closest to your specification',
     &       ' are :',//,T15,A10,' micro-inches RMS  ( ',
     &       'compared to',I6,' RMS )',//,15X,'All results ',
     &       'that follow will be based on this value.',// )
C
C          * * * * * * * * * *
C
C  Menu 4F  Ask for acceptable chip Quality
C
C          * * * * * * * * * *
C
 240        WRITE( 1,250 )
 250        FORMAT( //,10X,'Priority 2',
     &              //,10X,'Specify lowest chip Quality ',
     &                     'you can live with.' )
            DO 260 JCHIP = 1,NCHIPS
 260            WRITE( 1,'(T20,A50)' ) ACHIP( JCHIP )
                KCHIP = 0
                READ( 1,'(I1)', ERR = 240 ) KCHIP
                IF( KCHIP.LT.1 ) KCHIP = 1
                IF( KCHIP.GT.NCHIPS ) KCHIP = NCHIPS
                IF( KCHIP.GE.1.AND.KCHIP.LE.NCHIPS )  THEN
```

```
                    WRITE( 1,270 ) ACHIP( KCHIP )
 270                FORMAT( //////////,10X,'Only data for which ',
     &                          'chip Quality equals or exceeds',
     &                      //,T20,A50,//,10X,'will be considered.')
                 ELSE
                    WRITE( 1,280 ) NCHIPS
 280                FORMAT( //,10X,'Only numbers  1  to  ',
     &                          I2,' can be read.',
     &                      //,20x,'Please try again.',// )
                    GOTO 240
                 ENDIF
      ELSE
           IF( PRIORITY.EQ.'Q'.OR.PRIORITY.EQ.'q' )  THEN
C
C          * * * * * * * * * * * * * * * *
C    Branch for 1st priority = chip Quality
C
C
C    Menu 3Q     Ask for required chip Quality
C          * * * * * * * * * * * * * * * *
C
 290            WRITE ( 1, 300 )
 300            FORMAT( ///////////////,T10,'Priority 1',///,T30,
     &                    'Specify chip Quality you must have:',//)
                DO 310  ICHIPS = 1, NCHIPS
 310              WRITE ( 1, '(T20,A50)' )  ACHIP( ICHIPS )
                KCHIP = 0
                READ ( 1, '(I1)', ERR = 290 ) KCHIP
                IF ( KCHIP.LT. 1 )  KCHIP = 1
                IF ( KCHIP.GT.NCHIPS )  KCHIP = NCHIPS
                IF ( KCHIP.GE. 1 .AND. KCHIP.LE.NCHIPS ) THEN
                  WRITE ( 1, 270 )  ACHIP( KCHIP )
                ELSE
                  WRITE ( 1, 280 )  KCHIP
                  GOTO 290
                ENDIF
C
C          * * * * * * * * * * * *
C
C    Menu 4Q          Ask for acceptable surface finish
C
C          * * * * * * * * * * * *
C
 320            WRITE( 1,330 )
 330            FORMAT( //,T10,'Priority 2',///,T20,'Type in ',
     &                    'surface finish that would be acceptable in',
     &                    //,T20,'micro-inches RMS',//)
                READ ( 1, *, ERR = 320 )  FINISH
C
C          * * * * * * * * * * * * * * * *
C    Find CLOSEST finish number in data file to that specified.
C    NOTE:  SFINISHES must be read into appropriate DATA file from
C              the smallest to the largest.
C          * * * * * * * * * * * * * * * *
C
```

```
            IF ( FINISH.LE.SFINISH(1) ) THEN
              KFINISH = 1
              GOTO 350
            ELSE
              IF ( FINISH.GE.SFINISH( NFINISHS ) ) THEN
                KFINISH = NFINISHS
                GOTO 350
              ELSE
                DO 340  IFINISHS = 1,NFINISHS-1
                  IF ( FINISH.GT.SFINISH( IFINISHS+1 ) .OR.
     &                 FINISH.LT.SFINISH( IFINISHS ) )  GOTO 340
                  IF (( SFINISH(IFINISHS+1) - FINISH ).LE.
     &                 ( FINISH - SFINISH(IFINISHS) ) )  THEN
                    KFINISH = IFINISHS + 1
                  ELSE
                    KFINISH = IFINISHS
                  ENDIF
340               CONTINUE
              ENDIF
            ENDIF
350       WRITE ( 1, 230 )  FINISH, SFINISHCH( KFINISH ),
     &                      SFINISH( KFINISH )
          ELSE
C
C   *******  Escape from wrong response to  Menu 2
C
              WRITE( 1,360 )
360           FORMAT( 10X,'Only the letter  F  or  Q  can be read ',
     &                    'as a response.',//,
     &                 10X,'Please try again.',// )
              GOTO 150
          ENDIF
      ENDIF
C
C           * * * * * * * * * * * * * * * * *
C   End of  "Surface Finish - chip Quality" Priority branching.
C
C
C   Menu 5  Ask for Depth Of Cut
C           * * * * * * * * * * * * * * * * *
C
370       WRITE( 1,380 )
380       FORMAT( //,20X,'Type the Depth Of Cut you want in ',
     &              //,25X,'thousandths of an inch.',//,
     &              13X,'( Finishing - DOC = 0.060" : Roughing -',
     &                   ' 0.200" )',// )
C
          READ( 1,*, ERR = 370 ) DOC
C
C           * * * * * * * * * * * * * * *
C   Find the CLOSEST DEPTH in the data file to DOC specified.
C   Note  -  DEPTHS must be read into DATA from the
C                  smallest DEPTH to the largest.
C           * * * * * * * * * * * * * * *
C
```

```
            IF( DOC.LE.DEPTH(1) )  THEN
                  JDEPTH = 1
                  GOTO 400
            ELSE
                  IF(  DOC.GE.DEPTH( NDEPTHS )   )  THEN
                        JDEPTH = NDEPTHS
                        GOTO 400
                  ELSE
                        DO 390 IDEPTH = 1,NDEPTHS - 1
                              IF(  DOC.GT.DEPTH( IDEPTH + 1 )
     &                          .OR.DOC.LE.DEPTH( IDEPTH )  )  THEN
                                    GOTO 390
                              ENDIF
                              IF(  ( DEPTH( IDEPTH + 1 ) - DOC ).LE.
     &                              ( DOC - DEPTH( IDEPTH ) )  )  THEN
                                    JDEPTH = IDEPTH + 1
                              ELSE
                                    JDEPTH = IDEPTH
                              ENDIF
 390                    CONTINUE
                  ENDIF
            ENDIF
 400        WRITE( 1,410 ) DOC/1000.,DEPTH( JDEPTH )/1000.
 410        FORMAT( //,15X,'You asked for a',F8.3,
     &                    '   inch Depth Of Cut.',
     &              //,20X,'The DEPTH for which test results are ',
     &                     'available',
     &               /,20X,' that is closest to your request is ',
     &              //,T25,F10.3,'  inch',
     &              //,15X,'All results that follow will be based',
     &                     ' on this value.',// )
C
C           * * * * * * * * * * * * * * * * *
C
C  Menu 7  -  Choice of Feed OPTIONS
C
C           * * * * * * * * * * * * * * * * *
C
 420  WRITE( 1,430 )
 430  FORMAT( //,10X,'Choose Feed OPTION',///,
     &           T20,'1   User SPECIFIED Feed',//,
     &           T20,'2   All available Feed DATA that satisfy',
     &         /,T20,'    surface Finish  &  chip Quality criteria',
     &         /,T20,'    will be considered.',// )
C
C           * * * * * * * * * * * * * * *
C
C  Response 7  -  Feed OPTION
C
C           * * * * * * * * * * * * * * *
C
      READ( 1,'(A1)' ) FEDOPT
      IF( FEDOPT.EQ.'1' )  THEN
C
C           * * * * * * * * * * * *
```

```
C     Branch for User SPECIFIED Feed
C  Menu 8   Ask for FEED
C           * * * * * * * * * * * * *
C
 440        WRITE( 1,450 )
 450        FORMAT( ///////////,10X,'Feed Option 1  -  User Specified ',
     &              'Feed',///,T20,'Type the FEED you want in',//,
     &                T25,'thousandths of an inch / rev.',////// )
            READ( 1,*, ERR = 440 ) FED
C
C           * * * * * * * * * * * * * * *
C   Find the CLOSEST FEED in the data file to FED specified.
C   Note  -  FEEDs must be read into DATA from the
C                  smallest INCREASING to the largest.
C           * * * * * * * * * * * * * * *
C
            IF( FED.LE.FEED(1) )  THEN
                  JFEED = 1
                  GOTO 470
            ELSE
                  IF(  FED.GE.FEED( NFEEDS )  )  THEN
                        JFEED = NFEEDS
                        GOTO 470
                  ELSE
                        DO 460 IFEED = 1,NFEEDS - 1
                              IF(  FED.GT.FEED( IFEED + 1 )
     &                         .OR.FED.LE.FEED( IFEED )  )  THEN
                                    GOTO 460
                              ENDIF
                              IF(  ( FEED( IFEED + 1 ) - FED ).LE.
     &                              ( FED - FEED( IFEED ) )  )  THEN
                                    JFEED = IFEED + 1
                              ELSE
                                    JFEED = IFEED
                              ENDIF
 460                    CONTINUE
                  ENDIF
            ENDIF
 470        WRITE( 1,480 ) FED/1000.,FEED( JFEED )/1000.
 480        FORMAT( //,15X,'You asked for a',F8.3,
     &                  '  inch / rev. Feed.',
     &               //,20X,'The FEED for which test results are ',
     &                  'available',
     &                /,20X,' that is closest to your request is ',
     &               //,T25,F10.3,'  inch / rev.',
     &               //,15X,'All results that follow will be based',
     &                  ' on this value.',// )
C
      ELSE
            IF( ANSWER.EQ.'2' )  THEN
                  FED = 0.00
                  JFEED = 0
                  WRITE( 1,490 )
 490              FORMAT( ////,10X,'Feed OPTION  2',
     &                //,20X,'All econ for ALL  available Feed data ',
```

```
     &                    /,20X,'satisfying the specified ',
     &                    /,20x,'finish and chip criteria. ',// )
                  ELSE
C
C    **********  Escape from wrong response to Menu 7
C
                     WRITE( 1,500 )
  500                FORMAT( 20X,'Only the numbers 1 or 2 can be read ',
     &                          'as a response.',//,
     &                       10X,'Please try again.',// )
                     GOTO 420
                  ENDIF
             ENDIF
C
C              * * * * * * * * * * * * * * * *
C  End of  "Feed OPTION"  branching.
C
C
C
C  SORT for  "surface Finish"  and  "chip Quality"
C              * * * * * * * * * * * * * * * *
C
       K = 1
       DO 520 INSERT = 1,NSERTS
            DO 510 IFEED = 1,NFEEDS
                 IF(  ( JFEED.NE.0 ).AND.( JFEED.NE.IFEED )  )GOTO 510
                 IF(  ( IFINISH( INSERT, JDEPTH, IFEED ).LE.IFINISH )
     &                .AND.(    ICHIP( INSERT, JDEPTH, IFEED ).LE.KCHIP  )
     &                .AND.( IFINISH( INSERT, JDEPTH, IFEED ).NE.0  )
     &                .AND.(    ICHIP( INSERT, JDEPTH, IFEED ).NE.0 ) ) THEN
                      KSERT( K ) = INSERT
                      KFEED( K ) = IFEED
                      K = K + 1
                 ENDIF
  510       CONTINUE
  520  CONTINUE
       KEEPER = K - 1
       IF ( KEEPER.EQ.0 )   GOTO 700
C
C              * * * * * * * * * * * * * * * *
C
C  Menu  9  -  Tool Life / Length Of Cut   OPTIONS
C
C              * * * * * * * * * * * * * * * *
C
  530  WRITE( 1,540 )
  540  FORMAT(  /,10X,'Choose Tool Life  OPTION.',
     &        //,20X,'1   user  specifies  Tool Life',
     &         /,20X,'2   user  specifies  Length Of Cut',
     &         /,20X,'3   user  specifies  Surface Speed',
     &         /,20X,'4   optimize tool life for  Lowest Cost',
     &         /,20X,'5   optimize tool life for  Maximum Output',
     &      //,17X,'Note:  Results are most reliable in the Tool Life',
     &                   ' range from',
     &         /,20X,'                    5  to  25  minutes. ',
```

```
     &          /,20X,'    Computations are limited to this range.' )
C
C         * * * * * * * * * * * * * * * * *
C
C  Response 9  -  Tool Life  OPTION
C
C         * * * * * * * * * * * * * * * * *
C
      READ( 1,'(I1)', ERR = 530 ) TOLOPT
      IF  ( TOLOPT.LT.1 .OR. TOLOPT.GT.5 )  GOTO 530
      IF ( TOLOPT.EQ.1 .OR. TOLOPT.EQ.2 .OR. TOLOPT.EQ.3 ) THEN
         GOTO 550
      ELSE
         COSTOPT = 'Y'
         GOTO 565
      ENDIF

550  WRITE ( 1,560 )
560  FORMAT ( ////////////////////,10X,'Would you like the Cost($) ',
    &        'per cubic inch given in the output?',/,25X,'( Y/N )',//)
     READ ( 1, '(A1)' ) COSTOPT
      IF ( COSTOPT.NE.'Y' .AND. COSTOPT.NE.'y' .AND.
    &      COSTOPT.NE.'N' .AND. COSTOPT.NE.'n' )  GOTO 550

565  WRITE ( 1,570 )
570  FORMAT (////////////////////,20X,'Type the Diameter Of ',
    &         'Workpiece in',//,30X,'inches.',// )
     READ ( 1,*, ERR = 565 ) DOC

      IF ( TOLOPT .EQ. 1 ) THEN
575      WRITE ( 1,580 )
580      FORMAT ( //,20X,'Type the Tool Life you need in ',//,
    &              30X,'minutes',// )
         READ ( 1,*, ERR = 575 ) TOOLIFE
     ENDIF

      IF ( TOLOPT .EQ. 2 ) THEN
585      WRITE ( 1,590 )
590      FORMAT ( //,20X,'Type the Length Of Cut you need in ',
    &              //,30X,'inches' )
         READ ( 1,*, ERR = 585 ) LOCUT
     ENDIF

      IF ( TOLOPT .EQ. 3 ) THEN
595      WRITE ( 1,600 )
600      FORMAT ( //,20X,'Type the Surface Speed you need in ',
    &              //,30X,'surface feet per minute' )
         READ ( 1,*, ERR = 595 ) SFPM
     ENDIF

      IF ( COSTOPT.EQ.'Y' .OR. COSTOPT.EQ.'y' ) THEN
610      WRITE ( 1,620 )
620      FORMAT ( //,20X,'Type the Time allowed to Change Inserts ',
    &              'in',//,30X,'minutes')
         READ ( 1,*, ERR = 610 ) CTI
```

```
630      WRITE ( 1,640 )
640      FORMAT ( //,20X,'Type apporoximate Cost per Edge for ',
     &              'inserts in',//,30X,'dollars / edge' )
         READ ( 1,*, ERR = 630 ) CPE
650      WRITE ( 1,660 )
660      FORMAT ( //,20X,'Type the Labor plus Overhead rate in ',
     &              //,30X,'dollars / hour' )
         READ ( 1,*, ERR = 650 ) RLO
      ENDIF
C
C           * * * * * * * * * * * * * * * * *
C
C  Compute  SPEED  ( surface feet / minute )
C      and  Real Metal Removal Rate  ( cubic inches / minute )
C  Find metal removal rate index for MAXimum MRR.
C
C           * * * * * * * * * * * * * * * * *
C
      AMAXMRR = 0.0
      M = 1
      MAX( M ) = 0
C
      DO 670 K = 1,KEEPER
         IF( TOLOPT.EQ.1 )  THEN
            TOLIFE( K ) = TOOLIFE
         ELSE
            IF( TOLOPT.EQ.2 )  THEN
               TOLIFE( K ) = (    ( LOCUT * PI * DOW )/
     &                         ( .012 * FEED( KFEED(K) )*
     &                      10.** TL_IMIN( KSERT(K),JDEPTH,KFEED(K) )   ))
     &              **( 1./( 1. - TL_PWR( KSERT(K),JDEPTH,KFEED(K) ) ))
            ELSE
               IF ( TOLOPT .EQ. 3 ) THEN
                  TOLIFE( K ) =
     &              ( 10 ** TL_IMIN( KSERT(K),JDEPTH,KFEED(K))/ SPPM )
     &               ** ( 1./ TL_PWR( KSERT(K),JDEPTH,KFEED(K)) )
               ELSE
                  IF ( TOLOPT .EQ. 4 ) THEN
                     TOLIFE( K ) =
     &                  ( 1./ TL_PWR( KSERT(K),JDEPTH,KFEED(K) )
     &                   - 1.) * ( TCI  +  60.* CPE / RLO  )
                  ELSE
                     TOLIFE( K ) =
     &                  ( 1./ TL_PWR( KSERT(K),JDEPTH,KFEED(K) ) - 1.)
     &                    * TCI
                  ENDIF
               ENDIF
            ENDIF
         ENDIF
         IF( TOLIFE(K).LT. 5 ) TOLIFE( K ) =  5.0
         IF( TOLIFE(K).GT.25 ) TOLIFE( K ) = 25.0
C
C
            SPEED(K) = 10.** TL_IMIN(  KSERT(K), JDEPTH, KFEED(K)  )/
     &       ( TOLIFE(K) ** TL_PWR(  KSERT(K), JDEPTH, KFEED(K)  ) )
```

```
C
            RPM(K) = 12.* SPEED(K)/( PI * DIA )
C
            LOC(K) = FEED( KFEED(K) )* RPM(K) * TOLIFE(K)/1000.
           ULOC(K) = FED              * RPM(K) * TOLIFE(K)/1000.
C
            RMRR(K) =.000012*SPEED(K)*DEPTH(JDEPTH)*FEED(KFEED(K))
            UMRR(K) =.000012 * SPEED(K) * DOC            * FED
C
            COST(K) = ( RLO*( TOLIFE(K) + TCI ) + CPE )/
     &                ( 60 * RMRR(K) * TOLIFE(K) )
C
C
            IF(   RMRR( K ).GT.AMAXMRR  )  THEN
                  AMAXMRR = RMRR( K )
                  MAX( M ) = K
            ENDIF
  670 CONTINUE
C
C          * * * * * * * * * * * * * * * *
C
C  Sort Keepers such that the MAXimum MRR is indexed  1st
C                decreasing to the minimum MRR.
C
C          * * * * * * * * * * * * * * * *
C
      BMAXMRR = 0.0
C
       DO 690 K=1,KEEPER
         DMRR(K)=RMRR(K)
         MAX(K)=K
690    CONTINUE
       DO 680 K=1,KEEPER
         J=K
685      IF (J.EQ.1) GOTO 680
         IF (DMRR(J).GT.DMRR(J-1)) THEN
           OTEMP=DMRR(J-1)
           ITEMP=MAX(J-1)
           DMRR(J-1)=DMRR(J)
           MAX(J-1)=MAX(J)
           DMRR(J)=OTEMP
           MAX(J)=ITEMP
           J=J-1
           GOTO 685
         ENDIF
680    CONTINUE

            AMAXMRR = BMAXMRR
            BMAXMRR = 0.0
C
C          * * * * * * * * * * * * * * * *
C
C  Output SORTed Inserts
C
C          * * * * * * * * * * * * * * * *
```

```
C
  700 IF( KEEPER.EQ.0 )  THEN
            WRITE( 1,710 )
 710        FORMAT(  ////////,10X,'NONE  of the Inserts tested meet ',
    &                    'your STRICT requirements.',
    &                //,10X,'If you can relax a requirement, ',
    &                       're-enter the program at ',
    &                //,20X,'one of the  OPTIONS  listed  below. ',
    &                //////,25X,'Enter any key to continue.',///)
            READ ( 1, '(A1)' )
            GOTO  1000
      ENDIF
 720  WRITE( 1,730 ) KEEPER
 730  FORMAT( /////////,10X,I5,' Insert - Feed combinations satisfy ',
    &                    'your specifications. ',
    &           ///,20X,'They will be listed according to their ,'
    &            //,20X,'           Metal  Removal  Rates.',
    &            //,20X,'The first will have the highest MRR .',
    &            //,20X,'           decreasing to the last.',
    &         ///,15X,'Enter any key to see the 1st PAGE of INSERTS.',// )
C
C
 740  READ( 1,'(A1)' ) APAGE
 750  WRITE( 1,'(///////////////////////////)' )
      K = 1
      DO 760 M = ( 1 + ( K - 1 )*20 ), KEEPER
            WRITE( 1,'(A79)' ) ASERT( KSERT( MAX(M) ) )
            IF(  ( M - K*20 ).GT.0  )  THEN
                  WRITE ( 1, 120 )
                  K = K + 1
                  READ ( 1, '(A1)' )  APAGE
            ENDIF
 760  CONTINUE
      M = 1
      IF ( KEEPER.EQ.21  .OR. KEEPER.EQ.42 )  THEN
         APAGE = 'Y'
         GOTO 785
      ENDIF
      WRITE( 1,770 )
 770  FORMAT( //,5X,'Enter "R" to Return to Option Menu.  Enter any ',
    &           'other key to continue.' )
 780  READ( 1,'(A1)' ) APAGE
 785  IF( APAGE.NE.'R'.AND.APAGE.NE.'r' )  THEN
 790     WRITE( 1, 800 )
 800     FORMAT( /////////,5X,'ENTER # OF OPTION WANTED:',//,
    &             10X,'1  to look at Output of an Individual Insert',//,
    &             10X,'2  to see All inserts in order of highest MRR',//,
    &             10X,'3  to see the List of sorted inserts',//,
    &             10X,'4  to see list of originally Inputted parameters',
    &          //,10X,'5  to see Definitions of terms used in line of ',
    &                 'NOTES on output',//,
    &             10X,'6  to Return to Option Menu',///)
         READ( 1,*,ERR=790 ) TOOLOPT

         IF ( TOOLOPT.LT.1 .OR. TOOLOPT.GT.6 )  GOTO 790
```

```
      IF ( TOOLOPT .EQ. 3 )  GOTO 750
      IF ( TOOLOPT .EQ. 4 )  THEN
        WRITE( 1, 810 ) FINISH, XCHIP(KCHIP), DOC/1000.
        IF ( FEDOPT .EQ. '1' ) THEN
          WRITE( 1, 820 ) FED/1000.
        ELSE
          WRITE( 1, '(/)' )
        ENDIF
        IF ( COSTOPT.EQ.'Y' .OR. COSTOPT.EQ.'y' ) THEN
          WRITE( 1, 830 ) TCI, CPE, RLO
        ELSE
          WRITE( 1, 805 )
805       FORMAT(//////////,22X,'ENTER <RETURN> TO CONTINUE')
        ENDIF
        READ( 1,'(A1)' ) ACONT
        GOTO 790

810     FORMAT( 22X,'ORIGINAL  INPUT  PARAMETERS',/,22X,
     &          '----------------------------',///,8X,
     &          'SURFACE FINISH  =  ',F6.0,'  micro-inches',//,8X,
     &          'CHIP QUALITY ',/,16X,A50,//,8X,
     &          'DEPTH OF CUT    =  ',F8.3,'  inch ')
820     FORMAT( /,8X,'FEED              =  ',F8.3,'  inch / rev.' )
830     FORMAT( /,8X,'COST INFORMATION:',//,12X,
     &        'INDEXING TIME         =  ',F6.1,'  minutes',//,12X,
     &        'COST/INSERT EDGE      =  $',F6.2,//,12X,
     &        'LABOR + OVERHEAD RATE =  $',F6.2,
     &        //,22X,'ENTER <RETURN> TO CONTINUE' )
      ELSE
        IF ( TOOLOPT .EQ. 5 ) THEN
          WRITE ( 1, 835 )
835         FORMAT(/,24X,'COMMENT DEFINITIONS',/,
     &      'Notch       -- Observed gradual formation of notch at ',
     &                    'D.O.C. line',/,
     &      2X,'Nose      -- Observed gouging of rake face on ',
     &                    'nose of insert',//,
     &      'Crater      -- Observed gradual formation of crater on ',
     &                    'the insert rake face',/,
     &      2X,'CE        -- Observed crater along cutting edge ',
     &                    'of chip breaker',//,
     &      'Sparking    -- Sparks were observed during entire ',
     &                    'time of cutting',/,
     &      2X,'End       -- Sparks were observed at cutting time ',
     &                    'during last .003" flank wear',/,
     &      2X,'Slight    -- Intermittent sparking observed',//,
     &      'Vibration   -- Vibration and chatter noise of workpiece'
     &                    ' during time of cutting',//,
     &      'BUE         -- Build up edge on insert cutting edge',//,
     &      'Nose Wear   -- Excessive flank wear observed at ',
     &                    'nose of insert',/,
     &      'Nose Def.   -- Deformation or melting of the nose tip',/,
     &      'CE Wear/Def-- Gradual breakdown of cutting edge during'
     &                    ' tool life of insert',//,
     &      'Qualifiers:',/,
     &      3X,'-ing      -- Behavior was observed during entire tool ',
```

```
     &                        'life to .010" flank wear',/,
     &          3X,'Slight  -- Behavior was observed during approx. ',
     &                        '0.005" flank wear',/,
     &          22X,'ENTER <RETURN> TO CONTINUE' )
                READ( 1,'(A1)' ) ATTIT
                GOTO 790
              ELSE
                IF ( TOOLOPT .EQ. 6 ) THEN
                  GOTO 1000
                ENDIF
              ENDIF
            ENDIF
840         IF ( TOOLOPT .EQ. 1 ) THEN
              WRITE( 1, 845 ) KEEPER
845           FORMAT(//////,10X,'ENTER any SEQUENTIAL Number ( 1 to ',
     &             I2,' ) from the list of inserts.',///)
              READ( 1,*,ERR=840 ) TOOLNO
              IF ( TOOLNO .LT. 0 .AND. TOOLNO .GT. KEEPER ) THEN
                GOTO 840
              ELSE
                IF ( TOOLNO .GT. 0 .AND. TOOLNO .LE. KEEPER ) THEN
                  IF ( FEDOPT .EQ. '2' ) THEN
                   WRITE ( 1, '(//)' )
                  ENDIF
                   WRITE( 1,'(A79)' ) ASERT( KSERT( MAX(TOOLNO) ) )
                   WRITE( 1,'(A79)' ) ANOTE( KSERT( MAX(TOOLNO) ) )
                   WRITE( 1,850 )
     &                 ACHIP(     ICHIP( KSERT( MAX(TOOLNO) ), JDEPTH,
     &                                  KFEED( MAX(TOOLNO) )  )    )
                  IF ( FEDOPT .EQ. '2' ) THEN
                   WRITE ( 1, '(//)' )
                  ENDIF
                   WRITE( 1,860 )
     &               SFINISHCH(  IFINISH( KSERT( MAX(TOOLNO) ), JDEPTH,
     &                                  KFEED( MAX(TOOLNO) )  )    )
                   WRITE( 1,870 ) DEPTH( JDEPTH )/1000.
                   WRITE( 1,880 )  FEED( KFEED( MAX(TOOLNO) ) )/1000.
850                FORMAT(      5X,'Chip Quality = ',A50   )
860                FORMAT(  /,20X,'Surf. Finish = ',A10,
     &                        ' micro - inches ' )
870                FORMAT(     25X,'Depth of Cut = ',F8.3,'  inch ' )
880                FORMAT(     25X,'Feed         = ',F8.3,'  inch / rev.')
                   WRITE( 1,890 ) TOLIFE( MAX( TOOLNO )  )
890                FORMAT(     20X,'Tool Life     = ',F8.1,
     &                        ' minutes ' )
                   WRITE( 1,900 ) SPEED(  MAX( TOOLNO )  )
900                FORMAT(     20X,'Surface Speed= '.F8.0,
     &                        ' surface feet / minute ' )
                   WRITE( 1,910 ) RATE(  MAX( TOOLNO )  )
910                FORMAT(     20X,'M. R. Rate    = ',F8.1,
     &                        ' cubic inches / minute ' )
                   WRITE( 1,920 ) DOW
920                FORMAT(     25X,'D. O. Workpc = ',F8.1,' inches ' )
                   WRITE( 1,930 ) LOT(  MAX( TOOLNO )  )
930                FORMAT(     25X,'L. O. Cut     = ',F8.0,' inches ' )
```

```
                WRITE( 1,940 ) RPM(  MAX( TOOLNO )  )
940             FORMAT(     20X,'R. P. M.      = ',F8.0,
     &                       ' rev. / minute' )
              IF( COSTOPT.EQ.'Y' .OR. COSTOPT.EQ.'y' )  THEN
                WRITE( 1,950 ) COST(  MAX( TOOLNO )  )
950             FORMAT(     20X,'Cost          =  $',F6.2,
     &                      ' per cubic inch ' )
              ELSE
                WRITE ( 1, '(/)' )
              ENDIF
              IF ( FEDOPT .EQ. '2' ) THEN
                WRITE ( 1, '(//)' )
              ELSE
                WRITE( 1,960 )
960             FORMAT(  /,10X,'Computations for user specified',
     &                      ' Depth Of Cut  and  Feed . ')
                WRITE( 1,965 ) DOC/1000.
965             FORMAT(     25X,'D. O. Cut     = ',F8.3,'  inch' )
                WRITE( 1,970 ) FED/1000.
970             FORMAT(     25X,'Feed          = ',F8.3,'  inch / rev.')
                WRITE( 1,975 ) UMRR(  MAX( TOOLNO )  )
975             FORMAT(     20X,'M. R. Rate    = ',F8.1,
     &                      ' cubic inches / minute ' )
                WRITE( 1,980 ) ULOC(  MAX( TOOLNO )  )
980             FORMAT(     20X,'L. O. Cut     = ',F8.0,' inches' )
              ENDIF
                WRITE( 1,985 )
985             FORMAT(  /,5X,'Enter "R" to Return to Option Menu.',
     &                3X,'Enter any other key to continue.')
                GOTO 780
              ENDIF
            ENDIF
          ELSE
            IF ( TOOLOPT .EQ. 2 ) THEN
990             IF( APAGE.NE.'R'.AND.APAGE.NE.'r' )  THEN
995                 IF( M.LE.KEEPER )  THEN
                      IF ( FEDOPT .EQ. '2' ) THEN
                        WRITE ( 1, '(//)' )
                      ENDIF
                        WRITE( 1,'(A79)') ASERT( KSERT( MAX( M)))
                        WRITE( 1,'(A79)') ANOTE( KSERT( MAX(M)))
                        WRITE( 1,850 )
     &                      ACHIP(     ICHIP( KSERT( MAX(M) ),
     &                           JDEPTH, KFEED( MAX(M) )  )    )
                      IF ( FEDOPT .EQ. '2' ) THEN
                        WRITE ( 1, '(//)' )
                      ENDIF
                        WRITE( 1,860 )
     &                    SFINISHCH(   IFINISH( KSERT( MAX(M) ),
     &                              JDEPTH, KFEED( MAX(M) ) ) )
                        WRITE( 1,870 ) DEPTH( JDEPTH )/1000.
                        WRITE( 1,880 ) FEED(KFEED(MAX(M)))/1000.
                        WRITE( 1,890 ) TOLIFE(  MAX( M )  )
                        WRITE( 1,900 ) SPEED(  MAX( M )  )
                        WRITE( 1,910 ) RMRR(  MAX( M )  )
```

```
                              WRITE( 1,920 ) DOW
                              WRITE( 1,930 ) LOC(  MAX( M )  )
                              WRITE( 1,940 ) RPM(  MAX( M )  )
                            IF( COSTOPT.EQ.'Y' .OR. COSTOPT.EQ.'y' )THEN
                              WRITE( 1,950 ) COST(  MAX( M )  )
                            ELSE
                              WRITE( 1,'(/)' )
                            ENDIF
                            IF ( FINOPT .EQ. '2' ) THEN
                              WRITE ( 1, '(//)' )
                            ELSE
                              WRITE( 1,960 )
                              WRITE( 1,965 ) DOC/1000.
                              WRITE( 1,970 ) FED/1000.
                              WRITE( 1,975 ) UFER(  MAX( M )  )
                              WRITE( 1,980 ) ULOC(  MAX( M )  )
                            ENDIF
                              WRITE( 1,985 )
                              READ( 1, '(A1)' ) APAGE
                              M = M + 1
                              GOTO 900
                         ENDIF
                     ENDIF
                 ENDIF
               ENDIF
             ENDIF
 1000                WRITE( 1,1100 )
 1100                FORMAT(  /////////////,10X,'Re-enter program at  ',
     &                    'Options for :',//,20X,'1   Shape of Insert ',
     &                    '( the beginning )',/,20X,'2   Finish and ',
     &                    'Chip priority ',/,20X,'3   Feed ',
     &                    /,20X,'4   Tool Life / Length of Cut ',
     &                    /,20X,'5   Repeat of Results ',
     &                 //,17X,'Exit   enter any other key ', //////)
                      READ( 1,'(A1)' ) APAGE
                      IF( APAGE.EQ.'2' ) GOTO    180
                      IF( APAGE.EQ.'3' ) GOTO    420
                      IF( APAGE.EQ.'4' ) GOTO    530
                      IF( APAGE.EQ.'5' ) GOTO    700
 9999  CLOSE (MUNIT)

       RETURN
       END


       SUBROUTINE F_TRIANGLE
C
C       VARIABLE DECLARATIONS
C
       CHARACTER*11 DFILETRI
       CHARACTER*15 GEOM_NAME
C
C        VARIABLE INITIALIZATION
C
```

```
      NUNIT5 = 5
      DFILETRI = 'F_TRIDATA'
      GEOM_NAME = '   TRIANGULAR    '
C
C     CALL THE GENERAL SORTING SUBROUTINE
C
C
      CALL GEN_SORT( NUNIT5, DFILETRI, GEOM_NAME )

      RETURN
      END

      SUBROUTINE F_SQUARE
C
C       VARIABLE DECLARATIONS
C
      CHARACTER*11  DFILESQU
      CHARACTER*15  GEOM_NAME
C
C      VARIABLE INITIALIZATION
C
      NUNIT6 = 6
      DFILESQU = 'F_SQUDATA'
      GEOM_NAME = '      SQUARE     '
C
C        CALL GENERAL SORTING SUBROUTINE
C
C
      CALL GEN_SORT( NUNIT6, DFILESQU, GEOM_NAME )

      RETURN
      END

      SUBROUTINE F_C_DIAMOND_80
C
C      VARIABLE DECLARATIONS
C
      CHARACTER*11  DFILEC80
      CHARACTER*15  GEOM_NAME
C
C      VARIABLE INITIALIZATION
C
C
      NUNIT7 = 7
      DFILEC80 = 'F_DIA80DATA'
      GEOM_NAME = 'DIAMOND(80 DEG)'
C
C      CALL GENERAL SORTING SUBROUTINE
C
C
      CALL GEN_SORT( NUNIT7, DFILEC80, GEOM_NAME )
```

```
      RETURN
      END

      SUBROUTINE F_D_DIAMOND_55
C
C      VARIABLE DECLARATIONS
C
      CHARACTER*11   DFILEDM
      CHARACTER*15   GEOM_NAME
C
C      VARIABLE INITIALIZATION
C
      MUNIT8 = 8
      DFILEDM = 'F_DIA55DATA'
      GEOM_NAME = 'DIAMOND(55 DEG)'
C
C      CALL GENERAL SORTING SUBROUTINE
C
C
      CALL GEN_SORT( MUNIT8, DFILEDM, GEOM_NAME )

      RETURN
      END

      SUBROUTINE F_ROUND
C
C      VARIABLE DECLARATIONS
C
      CHARACTER*11   DFILEROU
      CHARACTER*15   GEOM_NAME
C
C      VARIABLE INITIALIZATION
C
      MUNIT9 = 9
      DFILEROU = 'F_ROUDATA'
      GEOM_NAME = '     ROUND      '
C
C      CALL GENERAL SORTING SUBROUTINE
C
C
      CALL GEN_SORT( MUNIT9, DFILEROU, GEOM_NAME )

      RETURN
      END

      SUBROUTINE R_TRIANGLE
C
C       VARIABLE DECLARATIONS
```

```
C
      CHARACTER*11   DFILETRI
      CHARACTER*15   GEOM_NAME
C
C        VARIABLE INITIALIZATION
C
      NUNIT5 = 5
      DFILETRI = 'R_TRIDATA'
      GEOM_NAME = '   TRIANGULAR    '
C
C     CALL THE GENERAL SORTING SUBROUTINE
C
      CALL GEN_SORT( NUNIT5, DFILETRI, GEOM_NAME )


      RETURN
      END


      SUBROUTINE R_SQUARE
C
C       VARIABLE DECLARATIONS
C
      CHARACTER*11   DFILESQU
      CHARACTER*15   GEOM_NAME
C
C      VARIABLE INITIALIZATION
C
      NUNIT6 = 6
      DFILESQU = 'R_SQUDATA'
      GEOM_NAME = '      SQUARE      '
C
C       CALL GENERAL SORTING SUBROUTINE
C
      CALL GEN_SORT( NUNIT6, DFILESQU, GEOM_NAME )


      RETURN
      END


      SUBROUTINE R_DIAMOND_80
C
C       VARIABLE DECLARATIONS
C
      CHARACTER*11   DFILED80
      CHARACTER*15   GEOM_NAME
C
C       VARIABLE INITIALIZATION
C
      NUNIT7 = 7
      DFILED80 = 'R_DIA80DATA'
      GEOM_NAME = 'DIAMOND(80 DEG)'
C
C        CALL GENERAL SORTING SUBROUTINE
```

```
C
      CALL GEN_SORT( NUNIT7, DFILEOUT, GEOM_NAME )

      RETURN
      END

      SUBROUTINE R_D_DIAMOND_55
C
C        VARIABLE DECLARATIONS
C
      CHARACTER*11   DFILEDNM
      CHARACTER*15   GEOM_NAME
C
C        VARIABLE INITIALIZATION
C
      NUNIT8 = 8
      DFILEDNM = 'R_DIA55DATA'
      GEOM_NAME = 'DIAMOND(55 DEG)'
C
C       CALL GENERAL SORTING SUBROUTINE
C
      CALL GEN_SORT( NUNIT8, DFILEDNM, GEOM_NAME )

      RETURN
      END

      SUBROUTINE R_ROUND
C
C        VARIABLE DECLARATIONS
C
      CHARACTER*11   DFILEROU
      CHARACTER*15   GEOM_NAME
C
C        VARIABLE INITIALIZATION
C
      NUNIT9 = 9
      DFILEROU = 'R_ROUDATA'
      GEOM_NAME = '       ROUND)        '
C
C        CALL GENERAL SORTING SUBROUTINE
C
      CALL GEN_SORT( NUNIT9, DFILEROU, GEOM_NAME )

      RETURN
      END
```

Data File: F_TRIDATA

```
C1      TRIDATA( data file F for subroutine TRIANGLE called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5          The number of comment lines and their placement are fixed by program
C6          SORT.  However, the content may be altered or ommited.
C7
C8         INPUT the number of data entries in the order specified
C9         below.  These numbers MUST correspond to the number of entries
C10        for each category in this data file.
C11           NSERTS       NDEPTHS       NFEEDS      NFINISH      NQUIRS
                22            1            3            6            3
C12     INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13     Enter NDEPTHS numbers in thousandths of an inch from the
C14     smallest INCREASING to the largest.
          60
C15     INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16     Enter NFEEDS numbers in thousandths of an inch from the
C17     smallest INCREASING to the largest.
          12        17        20
C18     INPUT FINISHes  ( obtained from test data )  after comment line C20
C19     Enter NFINISH numbers in micro-inchs RMS  from the
C20     smallest INCREASING to the largest.
          63        90        125        180        250        320
C21     Enter SURFACE FINISH, corresponding to NFINISH numbers, how you
C22     would like them to be outputted in the program.
C23     Place each SFINISH on a separate line, starting the smallest RMS
C24     to the largest RMS.  Each SFINISH is allowed 10 characters,
C25     starting in Column 11.
C26          1         2         3
C27   678901234567890123456789 0
                63
                63+
               125
               125+
               250
               250+
C28     INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29     Enter NQUIRS lines describing chip categories used in data collection.
C30     Enter the BEST first, the WORST last.     Begin after comment line C30.
  1 - good,  all small chips,  no curls
  2 - fair,  50% small chips,  50% short curls
  3 - poor,  bird nest,  long curls,  etc.
C31     INPUT IDENTIFIER for each insert on separate lines up to 80 spaces wide,
C32     followed by NOTES or test observations  on a line  up to 80 spaces wide.
C33     Begin input of INSERT IDENTIFIER lines after this comment line C33.
  101   tool No. [illegible]  TPG -  [illegible] 312 - Al Ox   TNMG  432
   91   Note- 0.017" - Notching, 0.030" - Cratering
  102   tool No.           Carboloy [illegible] - Al Ox   TNMG  432 - 48
   92   Note- 0.015" - Slt Notching, 0.017" - Slt Sparking & Vibration
```

```
103   tool No. 50753   Carboloy  570 - Al Ox    TNMG    433 - 26
 03   Note-  < 0.017"-Slt Cratering, 0.017"-Nose Notch, 0.020"-Slt Crater
104   tool No.         Carboloy  570 - Al Ox    TNMP    433 - 16
 04   Note- < 0.017" - Cratering, 0.012" - Nose Wear, 0.020" - Slt Crater
105   tool No. 50752   Carboloy  570 - Al Ox    TNMA    433 - 52
 05   Note-  < 0.017" - Slight Notching, 0.020" - Slight Vibration
106   tool No.         Cleveland CP1 - Al Ox    TNMG    433
 06   Note- <0.017" - Slt Notch, 0.012" - Sparking, 0.020" - Slt Notching
107   tool No.         Cleveland CP1 - Al Ox    TNMP    432 - 41
 07   Note-  All Feeds - Nose Wear, 0.012" - Sparking
108   tool No.         Carmet - 7000 - Al Ox    TNMG    433 - F
 08   Note- 0.012-Sl Notching&Sparking,0.017-NoseDef&Notching,0.020-Sl Notch
109   tool No. 50237   Sandvik - 015 - Al Ox    TNMG    433 - 61
 09   Note-  All Feeds - Cratering, 0.017" - Notch
110   tool No.         Firth SterlingCC46-AlOx TNMG    433
 10   Note- 0.012"-Slt Notching,0.017"-Notch&Sparking,0.020"-Notching&Crater
111   tool No.         Valenite- V01 - Al Ox    TNMM    433 - EP
 11   Note- 0.017" - Notching, 0.020" - Slight Vibration & Crater
112   tool No.         Valenite- V01 - Al Ox    TNMM    432 - EFE
 12   Note- <0.017"- Slt Notch(CE or Nose), 0.020"- Slt Crater & Sparking
113   tool No.         Valenite- V05 - Al Ox    TNMG    433
 13   Note- 0.012" - Slight Notch, 0.017" - Slight Sparking
114   tool No.         Newcomer-NA02 - Al Ox    TNMG    433
 14   Note- 0.012" & 0.020" - Slight Notching, 0.017" - Slight Notch
115   tool No.         Kennametal 050- Multi    TNMG    433 - K
 15   Note-  All Feeds - Slight Notching
116   tool No. 50754   Kennametal 050- Multi    TNMM    433
 16   Note- 0.012" & 0.020"- Slt Notching,0.017"- Slt Notch,0.020"-Cratering
117   tool No.         Seco  -   TP15- Multi    TNMM    433 - 27
 17   Note- <0.017-Slt Cratering,0.012-Notching,0.017-NoseWr,0.020-Slt Notch
118   tool No.         Seco  -   TP10- Multi    TNMM    433 - 27
 18   Note- <0.017"- Cratering,0.012"- Nose Notch,0.020"- Slight Cratering
119   tool No.         Cleveland CM2 - Multi    TNMP    433 - 41
 19   Note-  0.012" - Slight Notch
120   tool No. 50261   Sandvik - 415 - Multi    TNMM    433 - 71
 20   Note- 0.012" & 0.020"- Slight Crater & Notching, 0.020"- Notching
121   tool No. 50264   Sandvik - 425 - Multi    TNMM    433 - 71
 21   Note-  All Feeds - Cratering, 0.012" - Notching
122   tool No. 50751   VR/Wesson 680 - Multi    TNMM    433
 22   Note-  > 0.017" - Slight Cratering
123   tool No.         VR/Wesson 680 - Multi    TNMG    433 - E
 23   Note-  > 0.017" - Slight Crater
C24
C25
C26   INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C27   Finish and chip Qualities are indicated by the integer corresponding to
C28   catagories entered above. These are followed by the COEFFICIENT and POWER
C29   ( used in the tool-life, speed equation )  from the data for each test.
C40
C41   ALL of the above values will appear on each line of data entered and be
```

```
C42   READ from DO LOOPs structured as follows - -
C43
C44   For each INSERT -
C45         DEPTH 1
C46              Feed 1
C47              Feed 2
C48              ...
C49              Feed n  ( over the range of feeds input after line C17 above )
C50         DEPTH 2
C51              Feed 1
C52              Feed 2
C53              ...
C54              Feed n
C55          ....
C56         DEPTH m ( over the range of depths input after comment line C14 )
C57              Feed 1
C58              ...
C59   Skip a line ( or put in a comment line ) before each INSERT data set.
C60   Next INSERT
C61         DEPTH 1
C62               Feeds
C63               etc.
C64   Skip etc
C65
C66   Enter a zero if no data was taken for a particular DEPTH and FEED.
C67   Begin entrys after comment line  C73
C68   Put entrys in  7  positions of  10  spaces each as shown from C69 to C72.
C69        1         2         3         4         5         6         7
C70  678901234567890123456789012345678901234567890123456789012345678901234567890
C71 INSERT    DEPTH     FEED      FINISH    CHIP      COEF-     POWER
C72 INDEX     INDEX     INDEX     INDEX     INDEX     FICIENT   EXPONENT
C73
This line following comment line C73 is the SKIP line before first INSERT 101.
       101         1         1         3         2    2.8574      .15
       101         1         2         4         1    3.0597      .40
       101         1         3         5         1    3.0425      .32
skip
       102         1         1         3         3    2.8258      .10
       102         1         2         4         2    2.8420      .15
       102         1         3         5         1    2.7015      .15
skip
       103         1         1         3         1    2.2480      .58
       103         1         2         4         1    2.0397      .22
       103         1         3         5         1    2.8851      .24
skip
       104         1         1         3         1    3.1555      .35
       104         1         2         4         1    3.1120      .37
       104         1         3         5         1    3.1040      .45
skip
       105         1         1         3         3    3.1451      .31
```

	105	1	2	3	1	2.8911	.17
	105	1	3	6	2	3.0742	.42
skip							
	106	1	1	2	3	3.0164	.23
	106	1	2	4	2	2.9443	.21
	106	1	3	6	1	2.8866	.20
skip							
	107	1	1	4	1	3.0808	.23
	107	1	2	5	1	2.9411	.21
	107	1	3	6	1	2.8829	.22
skip							
	108	1	1	3	2	3.1160	.29
	108	1	2	4	2	2.9715	.29
	108	1	3	4	1	2.7608	.12
skip							
	109	1	1	3	1	2.9942	.27
	109	1	2	4	1	2.8567	.22
	109	1	3	6	1	2.7455	.11
skip							
	110	1	1	2	3	3.0676	.20
	110	1	2	4	1	3.0622	.24
	110	1	3	5	1	2.8961	.24
skip							
	111	1	1	2	3	2.7959	.14
	111	1	2	3	3	2.9311	.23
	111	1	3	5	3	2.9162	.27
skip							
	112	1	1	3	2	3.0742	.26
	112	1	2	4	1	2.9000	.15
	112	1	3	5	1	2.9255	.27
skip							
	113	1	1	3	2	2.9884	.20
	113	1	2	3	1	2.9454	.17
	113	1	3	4	1	2.7640	.15
skip							
	114	1	1	3	2	2.8800	.17
	114	1	2	4	1	2.8981	.28
	114	1	3	4	1	2.9723	.28
skip							
	115	1	1	2	1	2.9486	.16
	115	1	2	3	1	2.9991	.15
	115	1	3	4	1	2.8592	.17
skip							
	116	1	1	2	3	3.0137	.19
	116	1	2	4	3	3.0345	.25
	116	1	3	5	2	2.9878	.27
skip							
	117	1	1	3	3	2.9254	.09
	117	1	2	4	1	3.0286	.25
	117	1	3	4	1	2.7640	.11

skip							
	118	1	1	2	1	2.9977	.22
	118	1	2	2	1	2.8468	.23
	118	1	2	4	1	2.8207	.21
skip							
	119	1	1	2	1	2.8074	.24
	119	1	2	2	1	2.8100	.20
	119	1	2	4	1	2.6825	.21
skip							
	120	1	1	2	2	2.9758	.17
	120	1	2	2	1	2.9258	.22
	120	1	2	5	1	2.8206	.18
skip							
	121	1	1	2	2	2.1288	.21
	121	1	2	4	2	2.0520	.20
	121	1	2	5	2	2.0270	.22
skip							
	122	1	1	2	2	2.8882	.09
	122	1	2	2	1	2.8051	.09
	122	1	2	5	1	2.9004	.16
skip							
	123	1	1	2	2	2.8051	.22
	123	1	2	2	1	2.8122	.24
	123	1	2	4	1	2.7100	.12

Data File: F_SQUDATA

```
C1     SQUDATA( data file 6 for subroutine SQUARE called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5          The number of comment lines and their placement are fixed by program
C6          SORT.  However, the content may be altered or ommited.
C7
C8        INPUT the number of data entries in the order specified
C9        below.  These numbers MUST correspond to the number of
C10       entries for each category in this data file.
C11          NSERTS     NDEPTHS     NFEEDS       NFINISHS      NCHIPS
               12          1           3             6             3
C12    INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13    Enter NDEPTHS numbers in thousandths of an inch from the
C14    smallest INCREASING to the largest.
         60
C15    INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16    Enter NFEEDS numbers in thousandths of an inch from the
C17    smallest INCREASING to the largest.
         12       17       20
C18    INPUT FINISHes  ( obtained from test data )  after comment line C20
C19    Enter NFINISHS numbers in micro-inchs RMS  from the
C20    smallest INCREASING to the largest.
         63       90       125       180       250       320
C21    Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22    would like them to be outputted in the program.
C23    Place each SFINISH on a seperate line, starting with the smallest
C24    RMS to the largest RMS.  Each SFINISH is allowed 10 characters,
C25    starting in Column 11.
C26        1         2         3
C27   67890123456789012345678900
                63
                63+
                125
                125+
                250
                250+
C28    INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29    Enter NCHIPS lines describing chip catagories used in data collection.
C30    Enter the BEST first, the WORST last.    Begin after comment line C30.
   1 - good   all small chips,  no curls
   2 - fair,  70% small chips,  30% short curls
   3 - poor,  bird cage,  long curls,  etc.
C31    INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32    followed by NOTES on test observations   on a line  up to 80 spaces wide.
C33    Begin input of INSERT IDENTIFIER lines after this comment line C33.
  201    tool No. 50067    TPW -     018 - Al Ox   SNMG  432
   01    Note-  < 0.017" - Notching, 0.020" - Slight Notching
  202    tool No. 50746    Carboloy  545 - Al Ox   SNMM  432 - 53
   02    Note-  0.012" - Slight Nose Notch,    0.017" - End Sparking
```

```
203  tool No. 50744    Cleveland CP1 - Al Ox   SNMG   #32
 03  Note-  All Feeds - Crater, 0.012" - Nose Wear, 0.017" - Nose Def.
204  tool No.          Carmet - 7000 - Al Ox   SNMG   #32 - E
 04  Note-  All Feeds - Cratering, 0.012"- Nose Notching, 0.017"- Notching
205  tool No. 50748    Firth SterlingCCH6-AlOx SNMG   #32
 05  Note-  All Feeds - Slight Notch
206  tool No. 50747    Valenite  V05 - Al Ox   SNMG   #32
 06  Note-  0.012"- Slt Notching,   0.017"- Slt Notch, 0.020"- Slt Crater
207  tool No. 50749    Kennametal 250- Multi   SNMM   #32
 07  Note-  0.012" - Slt Notch,    0.017" - Slt Notching, 0.017" - Crater
208  tool No. 50745    Seco -   TP10 - Multi   SNMM   #32 - 27
 08  Note- 0.012"-Slt Notch,0.017"-Slt Notching,0.020"-Cratering&Nose Notch
209  tool No.          Seco -   TP15 - Multi   SNMM   #32 - 27
 09  Note-  0.012" - Slight BUE & Cratering, 0.017" - Slight Notching
210  tool No.          Cleveland CM2 - Multi   SNMG   #32
 10  Note-  All Feeds - Slight Notching
211  tool No. 50750    Sandvik - 415 - Multi   SNMM   #32 - 71
 11  Note-  0.012" & 0.020"- Slight Notch, 0.017" - Slight Notching
212  tool No.          VR/Wesson 680 - Multi   SNMG   #32
 12  Note-  < 0.017" - Slight Notch, 0.012" - Sparking
C34
C35
C36  INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C37  Finish and chip Qualities are indicated by the integer corresponding to
C38  catagories entered above. These are followed by the COEFFICIENT and POWER
C39  ( used in the tool-life, speed equation )  from the data for each test.
C40
C41  ALL of the above values will appear on each line of data entered and be
C42  READ from DO LOOPs structured as follows - -
C43
C44  For each INSERT -
C45        DEPTH 1
C46             Feed 1
C47             Feed 2
C48             ...
C49             Feed n   ( over the range of feeds input after line C17 above )
C50        DEPTH 2
C51             Feed 1
C52             Feed 2
C53             ...
C54             Feed n
C55          ....
C56        DEPTH m ( over the range of depths input after comment line C14 )
C57             Feed 1
C58             ...
C59  Skip a line ( or put in a comment line ) before each INSERT data set.
C60  Next INSERT
C61        DEPTH 1
C62              Feeds
C63              etc.
```

```
C64   Skip etc
C65
C66   Enter a zero if no data was taken for a particular DEPTH and FEED.
C67   Begin entrys after comment line C72
C68   Put entrys in  7  positions of  10  spaces each as shown from C69 to C72.
C69        1         2         3         4         5         6         7
C70  67890123456789012345678901234567890123456789012345678901234567890123456789
C71 INSERT    DEPTH     FEED      FINISH    CHIP      COEF-     POWER
C72 INDEX     INDEX     INDEX     INDEX     INDEX     FICIENT   EXPONENT
C73
This line following comment line C72 is the SKIP line before first INSERT 201.
       201        1         1         2         2       3.0221     .30
       201        1         2         4         2       2.8656     .10
       201        1         3         5         1       2.8508     .21
comment -     All data in this file was taken at ONE depth of cut.
       202        1         1         2         2       2.2531     .41
       202        1         2         3         2       2.9430     .22
       202        1         3         5         2       2.2065     .54
skip
       203        1         1         2         1       3.1711     .26
       203        1         2         4         1       2.0427     .21
       203        1         3         5         1       3.0155     .22
skip
       204        1         1         2         2       2.1058     .42
       204        1         2         4         2       2.8204     .15
       204        1         3         4         1       2.0590     .24
skip
       205        1         1         2         2       2.8141     .00
       205        1         2         3         1       2.9402     .23
       205        1         3         5         1       2.8505     .10
skip
       206        1         1         2         1       2.0177     .18
       206        1         2         3         1       2.8822     .15
       206        1         3         6         1       2.0044     .26
skip
       207        1         1         2         2       2.0000     .12
       207        1         2         3         1       2.0073     .27
       207        1         3         5         1       2.7012     .16
skip
       208        1         1         2         2       2.0552     .18
       208        1         2         2         2       2.8055     .17
       208        1         3         5         2       2.0244     .26
skip
       209        1         1         2         2       2.8653     .12
       209        1         2         4         1       2.0064     .30
       209        1         3         4         1       2.7006     .12
skip
       210        1         1         1         1       2.9526     .15
       210        1         2         4         1       2.7808     .16
       210        1         3         4         1       2.7256     .12
```

skip						
211	1	1	[illegible]	2	3.0576	.[illegible]
211	1	2	2	1	2.0056	.14
211	1	3	6	1	[illegible].0660	.25
skip						
212	1	1	[illegible]	1	2.0460	.10
212	1	2	2	1	2.0012	.32
212	1	2	4	1	2.8300	.36

Data File: F_DIA80DATA

```
C1     DIA80DATA( data file 7 for subroutine C_DIAMOND_80 called by program SORT
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5         The number of comment lines and their placement are fixed by program
C6         SORT.  However, the content may be altered or ommited.
C7
C8       INPUT the number of data entries in the order specified
C9       below.  These numbers MUST correspond to the number of
C10      entries for each category in this data file.
C11        NSERTS     NDEPTHS     NFEEDS     NFINISHS     NCHIPS
             17          1           3          6            3
C12    INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13    Enter NDEPTHS numbers in thousandths of an inch from the
C14    smallest INCREASING to the largest.
         60
C15    INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16    Enter NFEEDS numbers in thousandths of an inch from the
C17    smallest INCREASING to the largest.
         12        17        20
C18    INPUT FINISHes  ( obtained from test data )  after comment line C20
C19    Enter NFINISHS numbers in micro-inchs RMS  from the
C20    smallest INCREASING to the largest.
         63        90       125       180       250       320
C21    Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22    would like them to be outputted in the program.
C23    Place each SFINISH on a seperate line, starting with the smallest
C24    RMS to the largest RMS.  Each SFINISH is allowed 10 characters,
C25    starting in Column 11.
C26        1         2         3
C27   6789012345678901234567890
               63
               63+
              125
              125+
              250
              250+
C28    INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29    Enter NCHIPS lines describing chip catagories used in data collection.
C30    Enter the BEST first, the WORST last.    Begin after comment line C30.
  1 - good,  all small chips,  no curls
  2 - fair,  70% small chips,  30% short curls
  3 - poor,  bird cage,  long curls,  etc.
C31    INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32    followed by NOTES on test observations   on a line  up to 80 spaces wide.
C33    Begin input of INSERT IDENTIFIER lines after this comment line C33.
  301    tool No. 50742   TRW -            018 - Al Ox   CNMG   432
   01    Note-  0.012" - Notch,    0.017" - Slight Notching
  302    tool No.           Carboloy -     5H5 - Al Ox   CNMG   432 - 48
   02    Note-  < 0.017" - Sparking, 0.017" - Slight Cratering
```

```
303   tool No. 50741   Cleveland -     CP1 - Al Ox   CNMP    432 - 42
 03   Note- < 0.017" - Slight Notch, 0.020" - Notch
304   tool No.         Cleveland -     CP1 - Al Ox   CNMG    432
 04   Note- 0.012"-Notching & Nose Def, 0.017"-Slt CE Wear, 0.020"-Slt Notch
305   tool No.         Carmet -        7000 - Al Ox  CNMG    432 - E
 05   Note- 0.017" - Slight Sparking
306   tool No. 50120   Sandvik -       015 - Al Ox   CNMG    432 - 61
 06   Note- 0.012" - Crater, 0.017" - Notching, 0.020" - Cratering
307   tool No. 50742   Firth Sterling CC46- Al Ox   CNMG    432
 07   Note- 0.012" - Nose Notch, 0.017" - Slight Notching
308   tool No.         Valenite -      V05 - Al Ox   CNMG    432
 08   Note- 0.012" - Slight Notch, 0.017" - Slight Sparking
309   tool No.         Newcomer -      NA02 - Al Ox  CNMG    432
 09   Note- < 0.017" - Slight Notch, 0.017" - Nose Wear
310   tool No. 50009   Kennametal -    050 - Multi   CNMS    432
 10   Note- 0.012" - Slight Nose Notch, 0.017" - Slight Sparking
311   tool No.         Seco -          TP10 - Multi  CNMM    432 - 27
 11   Note- 0.012" - Slight Notch
312   tool No.         Seco -          TP15 - Multi  CNMM    432 - 27
 12   Note- 0.017" - CE Cratering & Slight Notch
313   tool No.         Cleveland -     CM2 - Multi   CNMP    432 - 42
 13   Note- All Feeds - Cratering
314   tool No.         Cleveland -     CM2 - Multi   CNMG    432
 14   Note- < 0.017" - Slight Notch, 0.020" - Crater
315   tool No. 50127   Sandvik -       415 - Multi   CNMG    432 - 15
 15   Note- 0.012" - Slight Notch, 0.020" - Slight Crater
316   tool No.         Sandvik -       435 - Multi   CNMG    432 - 61
 16   Note- 0.012" - Slight Cratering, 0.020" - Cratering
317   tool No. 50740   VR/Wesson -     680 - Multi   CNMM    432 - E
 17   Note- 0.017" - Slight Sparking
C24
C25
C26   INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C27   Finish and chip Qualities are indicated by the integer corresponding to
C28   catagories entered above. These are followed by the COEFFICIENT and POWER
C29   ( used in the tool-life, speed equation ) from the data for each test.
C40
C41   ALL of the above values will appear on each line of data entered and be
C42   READ from DO LOOPs structured as follows - -
C43
C44   For each INSERT -
C45         DEPTH 1
C46               Feed 1
C47               Feed 2
C48               ...
C49               Feed n  ( over the range of feeds input after line C17 above )
C50         DEPTH 2
C51               Feed 1
C52               Feed 2
C53               ...
```

```
C54                Feed n
C55             ....
C56             DEPTH m ( over the range of depths input after comment line C14 )
C57                Feed 1
C58                ...
C59    Skip a line ( or put in a comment line ) before each INSERT data set.
C60    Next INSERT
C61         DEPTH 1
C62                Feeds
C63                etc.
C64    Skip etc
C65
C66    Enter a zero if no data was taken for a particular DEPTH and FEED.
C67    Begin entrys after comment line C73
C68    Put entrys in 7 positions of 10 spaces each as shown from C69 to C72.
C69         1         2         3         4         5         6         7
C70  67890123456789012345678901234567890123456789012345678901234567890123456789
C71 INSERT   DEPTH     FEED      FINISH    CHIP      COEF-     POWER
C72 INDEX    INDEX     INDEX     INDEX     INDEX     FICIENT   EXPONENT
C73
This line following comment line C73 is the SKIP line before first INSERT 301.
       301       1         1         2         2     2.8048      .20
       301       1         2         2         2     2.8024      .17
       301       1         3         4         1     2.8233      .26
comment -     All data in this file was taken at ONE depth of cut.
       302       1         1         2         1     2.9009      .26
       302       1         2         2         1     2.7412      .16
       302       1         3         4         1     2.6478      .15
skip
       303       1         1         2         1     2.8917      .20
       303       1         2         4         1     2.9355      .21
       303       1         3         4         1     2.8300      .27
skip
       304       1         1         2         2     2.9366      .18
       304       1         2         4         2     2.8824      .26
       304       1         2         4         3     2.7372      .14
skip
       305       1         1         2         2     2.7814      .11
       305       1         2         2         2     2.7100      .12
       305       1         3         5         1     2.5402      .24
skip
       306       1         1         2         2     2.8533      .21
       306       1         2         4         1     2.8062      .22
       306       1         2         5         1     2.7920      .25
skip
       307       1         1         2         3     2.9050      .15
       307       1         2         3         1     2.9108      .30
       307       1         3         4         1     2.6710      .14
skip
       308       1         1         2         2     2.8022      .16
```

	308	1	1	2	2	2.7298	.17
	308	1	2	4	2	2.7186	.19
skip							
	309	1	1	2	2	2.0069	.34
	309	1	2	2	1	2.8728	.20
	309	1	2	4	1	2.7082	.22
skip							
	310	1	1	2	1	2.8457	.10
	310	1	2	2	2	2.9976	.28
	310	1	2	4	1	2.7692	.15
skip							
	311	1	1	2	1	2.1540	.44
	311	1	2	4	2	2.8132	.18
	311	1	2	5	2	2.9906	.21
skip							
	312	1	1	2	1	2.7764	.08
	312	1	2	2	1	2.8182	.24
	312	1	2	5	1	2.6289	.14
skip							
	313	1	1	2	1	2.7744	.22
	313	1	2	4	1	2.7456	.21
	313	1	2	5	1	2.5832	.12
skip							
	314	1	1	2	2	2.8688	.25
	314	1	2	4	3	2.7164	.12
	314	1	2	4	2	2.6526	.11
skip							
	315	1	1	2	1	2.8891	.17
	315	1	2	4	1	2.9132	.28
	315	1	2	5	1	2.7245	.13
skip							
	316	1	1	2	1	2.8462	.22
	316	1	2	4	1	2.6970	.15
	316	1	2	4	1	2.6768	.17
skip							
	317	1	1	2	1	2.9919	.16
	317	1	2	4	1	2.8547	.12
	317	1	2	4	1	2.7049	.17

```
C1     DIA55DATA' data file 8 for subroutine D_DIAMOND_55 called by program SORT
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5        The number of comment lines and their placement are fixed by program
C6        SORT.  However, the content may be altered or ommited.
C7
C8      INPUT the number of data entries in the order specified
C9      below.  These numbers MUST correspond to the number of
C10     entries for each category in this data file.
C11        NSERTS     NDEPTHS     NFEEDS     NFINISHS     NCHIPS
             9          1          3          6            3
C12   INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13   Enter NDEPTHS numbers in thousandths of an inch from the
C14   smallest INCREASING to the largest.
        60
C15   INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16   Enter NFEEDS numbers in thousandths of an inch from the
C17   smallest INCREASING to the largest.
        12       17       20
C18   INPUT FINISHes  ( obtained from test data )  after comment line C20
C19   Enter NFINISHS numbers in micro-inchs RMS  from the
C20   smallest INCREASING to the largest.
        63      90      125      180      250      320
C21   Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22   would like them to be outputted in the program.
C23   Place each SFINISH on a seperate line, starting with the smallest
C24   RMS to the largest RMS.  Each SFINISH is allowed 10 characters,
C25   starting in Column 11.
C26        1         2         3
C27  67890123456789012345678901234567890
               63
               63+
              125
              125+
              250
              250+
C28   INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29   Enter NCHIPS lines describing chip catagories used in data collection.
C30   Enter the BEST first, the WORST last.    Begin after comment line C30.
  1 - good,  all small chips,  no curls
  2 - fair,  70% small chips,  30% short curls
  3 - poor,  bird cage,  long curls,  etc.
C31   INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32   followed by NOTES on test observations   on a line  up to 80 spaces wide.
C33   Begin input of INSERT IDENTIFIER lines after this comment line C33.
 401    tool No. 50730    Carboloy -      570 - Al Ox    DNMG   433 - 48
  01    Note-  0.012"-Slt Notch, 0.017"-Slt Notching, 0.020"-Slt Crater&Notch
 402    tool No.          Carmet -       7000 - Al Ox    DNMG   433 - E
  02    Note-  0.012" - Slight Notch, 0.020" - Notching & BUE
```

```
 402   tool No.          Firth Sterling CC46- Al Ox   DNMG   432
  03   Note-  0.012" - Nose Notch, 0.017" - Sparking
 404   tool No.          Newcomer -     NA02 - Al Ox   DNMG   432
  04   Note- 0.012-Slt Notch & BUE,0.017-Slt Vibration,0.020-Notch & CE Def.
 405   tool No. 50138   Valenite -      V01 - Al Ox   DNMG   433
  05   Note-  0.012"- Vibration & Nose Notch, 0.020"- Slt Notch & Sparking
 406   tool No.          Seco -         TP10 - Multi   DNMM   442 - 27
  06
 407   tool No.          Seco -         TP15 - Multi   DNMM   442 - 27
  07
 408   tool No.          Sandvik -       415 - Multi   DNMG   432 - 15
  08
 409   tool No.          VR/Wesson -     680 - Multi   DNMG   432 - F
  09   Note-  0.012" - Nose Tip Notch
C24
C25
C26  INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C27  Finish and chip Qualities are indicated by the integer corresponding to
C28  catagories entered above. These are followed by the COEFFICIENT and POWER
C29  ( used in the tool-life, speed equation )  from the data for each test.
C40
C41  ALL of the above values will appear on each line of data entered and be
C42  READ from DO LOOPs structured as follows - -
C43
C44  For each INSERT -
C45          DEPTH 1
C46                Feed 1
C47                Feed 2
C48                ...
C49                Feed n  ( over the range of feeds input after line C17 above )
C50          DEPTH 2
C51                Feed 1
C52                Feed 2
C53                ...
C54                Feed n
C55          ....
C56          DEPTH m ( over the range of depths input after comment line C14 )
C57                Feed 1
C58                ...
C59  Skip a line ( or put in a comment line ) before each INSERT data set.
C60  Next INSERT
C61          DEPTH 1
C62                 Feeds
C63                 etc.
C64  Skip etc
C65
C66  Enter a zero if no data was taken for a particular DEPTH and FEED.
C67  Begin entrys after comment line C72
C68  Put entrys in 7 positions of 10 spaces each as shown from C69 to C72.
C69     1         2         3         4         5         6         7
```

```
C70  678901234567890123456789012345678901234567890123456789012345678901234567890
C71 INSERT   DEPTH     FEED     FINISH    CHIP     COEF-    POWER
C72 INDEX    INDEX     INDEX    INDEX     INDEX    FICIENT  EXPONENT
C73
This line following comment line C73 is the SKIP line before first INSERT 401.
       401       1        1        2        2     3.0821    .36
       401       1        2        4        1     2.1062    .32
       401       1        3        5        1     2.8270    .20
comment -    All data in this file was taken at ONE depth of cut.
       402       1        1        2        3     2.9107    .25
       402       1        2        4        2     2.8070    .20
       402       1        3        5        2     2.6755    .24
skip
       403       1        1        4        2     2.9060    .17
       403       1        2        4        1     2.7776    .22
       403       1        3        4        1     2.7720    .28
skip
       404       1        1        2        3     2.0920    .22
       404       1        2        4        3     2.8186    .22
       404       1        3        4        1     2.8526    .30
skip
       405       1        1        4        3     2.8040    .17
       405       1        2        4        3     2.8252    .22
       405       1        3        4        2     2.9174    .23
skip
       406       1        1        2        1     2.8252    .29
       406       1        2        4        2     2.6627    .19
       406       1        3        0        0     0.0000    .00
skip
       407       1        1        4        2     2.7640    .15
       407       1        2        4        1     2.6607    .21
       407       1        3        0        0     0.0000    .00
skip
       408       1        1        4        1     2.7110    .25
       408       1        2        2        1     2.6627    .22
       408       1        3        5        1     2.6075    .18
skip
       409       1        1        2        2     2.2230    .60
       409       1        2        3        1     2.6427    .15
       409       1        3        4        2     2.6003    .25
```

Data File: F_ROUDATA

```
C1      ROUDATA( data file 9 for subroutine ROUND called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5        The number of comment lines and their placement are fixed by program
C6        SORT.  However, the content may be altered or ommited.
C7
C8      INPUT the number of data entries in the order specified
C9      below.  These numbers MUST correspond to the number of
C10     entries for each category in this data file.
C11        NSERTS        NDEPTHS       NFEEDS       NFINISHS       NCHIPS
              7             1             4            6             3
C12    INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13    Enter NDEPTHS numbers in thousandths of an inch from the
C14    smallest INCREASING to the largest.
          60
C15    INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16    Enter NFEEDS numbers in thousandths of an inch from the
C17    smallest INCREASING to the largest.
          12       17       20       23
C18    INPUT FINISHes  ( obtained from test data )  after comment line C20
C19    Enter NFINISHS numbers in micro-inchs RMS  from the
C20    smallest INCREASING to the largest.
          63       90       125       180       250       320
C21    Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22    would like them to be outputted in the program.
C23    Place each SFINISH on a seperate line, starting with the smallest
C24    RMS to the largest RMS.  Each SFINISH is allowed 10 characters,
C25    starting in Column 11.
C26          1         2         3
C27   678901234567890123456789012
                63
                63+
                125
                125+
                250
                250+
C28    INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29    Enter NCHIPS lines describing chip catagories used in data collection.
C30    Enter the BEST first, the WORST last.    Begin after comment line C30.
  1 - good,  all small chips,  no curls
  2 - fair,  70% small chips,  30% short curls
  3 - poor,  bird cage,  long curls,  etc.
C31    INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32    followed by NOTES on test observations   on a line  up to 80 spaces wide.
C33    Begin input of INSERT IDENTIFIER lines after this comment line C33.
  501   tool No.          Carboloy -     54F - Al Ox   RNMG   43 - 40
   01   Note-  0.017" & 0.023" - Cratering, 0.023" - Notching
  502   tool No. 53755   Valenite -     V01 - Al Ox   RNMG   43
   02   Note-  0.017" & 0.020"- Slight DC Notch, 0.023"- Slight Notch
```

```
 503   tool No.          Valenite -      V05 - Al Ox   PNMG   43
  03   Note-  0.017" - Slight BUE
 504   tool No.          Greenleaf -     G1+ - Al Ox   PNMG   43
  04   Note-  0.012"-Slt CE Def, 0.017"-Slt BUE & Vibration, 0.020"-Vibration
 505   tool No. 50756    Kennametal -    950 - Multi   PNMG   43
  05   Note-  0.017" - Slight Cratering, 0.023" - Cratering
 506   tool No.          Sandvik -       415 - Multi   PNMG   43
  06   Note-  0.012" & 0.023"-Slt Notch,0.017"-Slt BUE,0.020"-Some Vibration
 507   tool No. 50757    VR/Wesson -     680 - Multi   PNMG   43
  07   Note-  0.017" & 0.020" - Some Vibration
C34
C35
C36   INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C37   Finish and chip Qualities are indicated by the integer corresponding to
C38   catagories entered above. These are followed by the COEFFICIENT and POWER
C39   ( used in the tool-life, speed equation )  from the data for each test.
C40
C41   ALL of the above values will appear on each line of data entered and be
C42   READ from DO LOOPs structured as follows - -
C43
C44   For each INSERT -
C45          DEPTH 1
C46                Feed 1
C47                Feed 2
C48                ...
C49                Feed n  ( over the range of feeds input after line C17 above )
C50          DEPTH 2
C51                Feed 1
C52                Feed 2
C53                ...
C54                Feed n
C55          ....
C56          DEPTH m ( over the range of depths input after comment line C14 )
C57                Feed 1
C58                ...
C59   Skip a line ( or put in a comment line ) before each INSERT data set.
C60   Next INSERT
C61          DEPTH 1
C62                 Feeds
C63                 etc.
C64   Skip etc
C65
C66   Enter a zero if no data was taken for a particular DEPTH and FEED.
C67   Begin entrys after comment line C73
C68   Put entrys in 7 positions of 10 spaces each as shown C69 to C72.
C69          1         2         3         4         5         6         7
C70  67890123456789012345678901234567890123456789012345678901234567890123456789
C71 INSERT    DEPTH     FEED      FINISH    CHIP      COEF-     POWER
C72 INDEX     INDEX     INDEX     INDEX     INDEX     FICIENT   EXPONENT
C73
```

This line following comment line 072 is the SKIP line before first INSERT 501.

501	1	1	0	0	0.0000	.00
501	1	2	1	2	2.0840	.26
501	1	3	1	2	2.1628	.41
501	1	4	2	1	2.0326	.16

comment - All data in this file was taken at ONE depth of cut.

502	1	1	0	0	0.0000	.00
502	1	2	1	2	2.1063	.29
502	1	3	1	2	2.0240	.20
502	1	4	4	2	2.2212	.42

skip

503	1	1	0	0	0.0000	.00
503	1	2	2	2	2.0982	.21
503	1	3	4	2	2.0008	.24
503	1	4	4	2	2.0140	.22

skip

504	1	1	1	2	2.1277	.21
504	1	2	2	2	2.0020	.25
504	1	3	2	2	2.0245	.26
504	1	4	4	2	2.0025	.28

skip

505	1	1	0	0	0.0000	.00
505	1	2	1	2	2.0717	.27
505	1	3	1	2	2.1024	.26
505	1	4	2	1	2.1225	.35

skip

506	1	1	1	2	2.2278	.52
506	1	2	2	2	2.1120	.22
506	1	3	1	2	2.0502	.21
506	1	4	4	2	2.0326	.21

skip

507	1	1	0	0	0.0000	.00
507	1	2	2	2	2.8821	.15
507	1	3	4	1	2.0403	.21
507	1	4	2	2	2.7742	.06

```
C1      TRIDATA( data file 5 for subroutine TRIANGLE called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5        The number of comment lines and their placement are fixed by program
C6        SORT.  However, the content may be altered or ommited.
C7
C8       INPUT the number of data entries in the order specified
C9       below.  These numbers MUST correspond to the number of entries
C10      for each category in this data file.
C11         NSERTS       NDEPTHS      NFEEDS    NFINISHS     NCHIPS
              7             1            3          6           3
C12   INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13   Enter NDEPTHS numbers in thousandths of an inch from the
C14   smallest INCREASING to the largest.
        200
C15   INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16   Enter NFEEDS numbers in thousandths of an inch from the
C17   smallest INCREASING to the largest.
        20       23       27
C18   INPUT FINISHes  ( obtained from test data )  after comment line C20
C19   Enter NFINISHS numbers in micro-inchs RMS  from the
C20   smallest INCREASING to the largest.
        180      250      330      375      500      600
C21   Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22   would like them to be outputted in the program.
C23   Place each SFINISH on a seperate line, starting the smallest RMS
C24   to the largest RMS.  Each SFINISH is allowed 10 characters,
C25   starting in Column 11.
C26       1         2         3
C27  678901234567890123456789 0
              125+
              250
              250+
            250-500
              500
              500+
C28   INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29   Enter NCHIPS lines describing chip catagories used in data collection.
C30   Enter the BEST first, the WORST last.    Begin after comment line C30.
   1 - good,  all small chips,  no curls
   2 - fair,  70% small chips,  30% short curls
   3 - poor,  bird cage,  long curls,  etc.
C31   INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32   followed by NOTES or test observations   on a line  up to 80 spaces wide.
C33   Begin input of INSERT IDENTIFIER lines after this comment line C33.
   101   tool NO.          Carboloy  570 - Al Ox    TNMM   543 - 85    (4140: 24)
    01   Note-  All Feeds - Screeching, 0.023" - Nose Wear, 0.027"- Sparking
   102   tool No.          TRW       018 - Al Ox    TNMG   543 - E     (4140: 24)
    02   Note-  0.027" - Slight Sparking
```

```
103  tool No.          Valenite  V05 - Al Ox   TNMG   543        (4140: 34)
 03  Note-  0.012" - Nose Wear, All Feeds - Slight Sparking
104  tool No.          Valenite  V05 - Al Ox   TNMM   543 - EP   (4140: 34)
 04  Note-  All Feeds - Screeching & Sparking, 0.022" - Nose Def.
105  tool No.          Kennametal 250- Multi   TNMM   543        (4140: 34)
 05  Note-  All Feeds - Sparking & Screeching
106  tool No. 50375    Sandvik   435 - Multi   TNMM   543 - 71   (4140: 34)
 06  Note-  All Feeds - Nose Wear
107  tool No.          Widalon   TK15 - Multi  TNMM   543 - 6    (4140: 34)
 07  Note-  0.020" - Nose Wear, > 0.022" - Screeching & Sparking
C34
C35
C36   INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C37   Finish and chip Qualities are indicated by the integer corresponding to
C38   catagories entered above. These are followed by the COEFFICIENT and POWER
C39   ( used in the tool-life, speed equation )  from the data for each test.
C40
C41   ALL of the above values will appear on each line of data entered and be
C42   READ from DO LOOPs structured as follows - -
C43
C44   For each INSERT -
C45          DEPTH 1
C46               Feed 1
C47               Feed 2
C48               ...
C49               Feed n  ( over the range of feeds input after line C17 above )
C50          DEPTH 2
C51               Feed 1
C52               Feed 2
C53               ...
C54               Feed n
C55          ....
C56          DEPTH m ( over the range of depths input after comment line C14 )
C57               Feed 1
C58               ...
C59   Skip a line ( or put in a comment line ) before each INSERT data set.
C60   Next INSERT
C61          DEPTH 1
C62                Feeds
C63                etc.
C64   Skip etc
C65
C66   Enter a zero if no data was taken for a particular DEPTH and FEED.
C67   Begin entrys after comment line  C72
C68   Put entrys in  7  positions of  10  spaces each as shown from C69 to C72.
C69       1         2         3         4         5         6         7
C70  67890123456789012345678901234567890123456789012345678901234567890123456789
C71 INSERT    DEPTH     FEED      FINISH    CHIP      COEF-     POWER
C72 INDEX     INDEX     INDEX     INDEX     INDEX     FICIENT   EXPONENT
C73
```

This line following comment line C73 is the SKIP line before first INSERT 101.

	101	1	1	2	2	2.8145	.18
	101	1	2	4	3	2.8222	.10
	101	1	3	4	2	2.8465	.25
skip							
	102	1	1	2	2	2.6962	.07
	102	1	2	4	1	2.8480	.24
	102	1	3	5	1	2.7013	.13
skip							
	103	1	1	4	1	2.8015	.07
	103	1	2	4	1	2.8943	.10
	103	1	3	5	1	2.6407	.05
skip							
	104	1	1	2	2	2.7970	.12
	104	1	2	4	3	2.6789	.05
	104	1	3	5	1	2.6830	.08
skip							
	105	1	1	3	3	2.8616	.19
	105	1	2	4	1	2.8305	.10
	105	1	3	4	2	2.8220	.22
skip							
	106	1	1	2	2	2.7120	.15
	106	1	2	4	1	2.6803	.11
	106	1	3	5	1	2.6458	.10
skip							
	107	1	1	2	1	2.7845	.14
	107	1	2	2	1	2.7855	.15
	107	1	3	4	1	2.8181	.26

```
C1     SQUDATA( data file 6 for subroutine SQUARE called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5        The number of comment lines and their placement are fixed by program
C6        SORT.  However, the content may be altered or ommited.
C7
C8      INPUT the number of data entries in the order specified
C9      below.  These numbers MUST correspond to the number of
C10     entries for each category in this data file.
C11        NSERTS     NDEPTHS     NFEEDS        NFINISHS      NCHIPS
            4            1           3             6             3
C12    INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13    Enter NDEPTHS numbers in thousandths of an inch from the
C14    smallest INCREASING to the largest.
         200
C15    INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16    Enter NFEEDS numbers in thousandths of an inch from the
C17    smallest INCREASING to the largest.
         20        23        27
C18    INPUT FINISHes  ( obtained from test data )  after comment line C20
C19    Enter NFINISHS numbers in micro-inches RMS  from the
C20    smallest INCREASING to the largest.
         180       250       330       375       500       600
C21    Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22    would like them to be outputted in the program.
C23    Place each SFINISH on a seperate line, starting with the smallest
C24    RMS to the largest RMS.  Each SFINISH is allowed 10 characters,
C25    starting in Column 11.
C26       1         2         3
C27  6789012345678901234567890
              125+
              250
              250+
            250-500
              500
              500+
C28    INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29    Enter NCHIPS lines describing chip catagories used in data collection.
C30    Enter the BEST first, the WORST last.    Begin after comment line C30.
   1 - good,  all small chips,  no curls
   2 - fair,  70% small chips,  30% short curls
   3 - poor,  bird cage,  long curls,  etc.
C31    INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32    followed by NOTES on test observations   on a line  up to 80 spaces wide.
C33    Begin input of INSERT IDENTIFIER lines after this comment line C33.
   201   tool No. 50026    Sandvik 415 - Multi   SNMM  643 - 71   (4140: 34)
    01   Note-  All Feeds - Sparking, > 0.023" - Nose Def.
   202   tool No.          Sandvik 435 - Multi   SNMM  643 - 71   (4140: 34)
    02   Note-
```

```
   203   tool No.          Seco    TP15 - Multi   SNMM   643 - 37   (4140: 24)
    03   Note- < 0.023" - End Sparking, 0.027" - Screeching
   204   tool No.          Widalon TK15 - Multi   SNMM   643 - 6    (4140: 24)
    04   Note-
C34
C35
C36    INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C37    Finish and chip Qualities are indicated by the integer corresponding to
C38    catagories entered above. These are followed by the COEFFICIENT and POWER
C39    ( used in the tool-life, speed equation )  from the data for each test.
C40
C41    ALL of the above values will appear on each line of data entered and be
C42    READ from DO LOOPs structured as follows - -
C43
C44    For each INSERT -
C45          DEPTH 1
C46                Feed 1
C47                Feed 2
C48                ...
C49                Feed n  ( over the range of feeds input after line C17 above )
C50          DEPTH 2
C51                Feed 1
C52                Feed 2
C53                ...
C54                Feed n
C55         ....
C56          DEPTH m ( over the range of depths input after comment line C14 )
C57                Feed 1
C58                ...
C59    Skip a line ( or put in a comment line ) before each INSERT data set.
C60    Next INSERT
C61          DEPTH 1
C62                 Feeds
C63                 etc.
C64    Skip etc
C65
C66    Enter a zero if no data was taken for a particular DEPTH and FEED.
C67    Begin entrys after comment line  C73
C68    Put entrys in  7  positions of  10  spaces each as shown from C69 to C72.
C69        1         2         3         4         5         6         7
C70  67890123456789012345678901234567890123456789012345678901234567890123456789
C71 INSERT    DEPTH     FEED      FINISH    CHIP      COEF-     POWER
C72 INDEX     INDEX     INDEX     INDEX     INDEX     FICIENT   EXPONENT
C73
This line following comment line C73 is the SKIP line before first INSERT 201.
       201         1         1         2         1    2.6218      .09
       201         1         2         2         1    2.7140      .20
       201         1         3         2         1    2.5456      .06
skip
       202         1         1         4         2    2.6404      .10
```

	202	1	2	3	1	2.5757	.10
	202	1	2	5	1	2.5085	.12
skip							
	203	1	1	2	2	2.4127	.17
	203	1	2	4	1	2.6159	.09
	203	1	2	4	1	2.6204	.12
skip							
	204	1	1	2	2	2.7451	.09
	204	1	2	4	2	2.8662	.22
	204	1	3	5	1	2.7122	.12

Data File: R_DIA80DATA

```
C1      DIA80DATA( data file 7 for subroutine C_DIAMOND_80 called by program SORT
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5          The number of comment lines and their placement are fixed by program
C6          SORT.  However, the content may be altered or ommited.
C7
C8        INPUT the number of data entries in the order specified
C9        below.  These numbers MUST correspond to the number of
C10       entries for each category in this data file.
C11         NSERTS      NDEPTHS       NFEEDS       NFINISHS       NCHIPS
              7            1            3             6             3
C12     INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13     Enter NDEPTHS numbers in thousandths of an inch from the
C14     smallest INCREASING to the largest.
          200
C15     INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16     Enter NFEEDS numbers in thousandths of an inch from the
C17     smallest INCREASING to the largest.
          20        23        27
C18     INPUT FINISHes  ( obtained from test data )  after comment line C20
C19     Enter NFINISHS numbers in micro-inchs RMS  from the
C20     smallest INCREASING to the largest.
          180       250       330       375       500       600
C21     Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22     would like them to be outputted in the program.
C23     Place each SFINISH on a seperate line, starting with the smallest
C24     RMS to the largest RMS.  Each SFINISH is allowed 10 characters,
C25     starting in Column 11.
C26         1         2         3
C27     67890123456789012345567890
               125+
               250
               250+
             250-500
               500
               500+
C28     INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29     Enter NCHIPS lines describing chip catagories used in data collection.
C30     Enter the BEST first, the WORST last.    Begin after comment line C30.
   1 - good,  all small chips,  no curls
   2 - fair,  70% small chips,  30% short curls
   3 - poor,  bird cage,  long curls,  etc.
C31     INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32     followed by NOTES on test observations   on a line  up to 80 spaces wide.
C33     Begin input of INSERT IDENTIFIER lines after this comment line C33.
   301    tool No.        TRW        955 - Al Ox   CNMG   643 - E    (4140: 34)
```

```
  01   Note-  0.020" - Slight Sparking
 302   tool No. 50024   TRW        918 - Al Ox   CNMG   643 - CF1   (4140: 24)
  02   Note-  0.027" - Slight Sparking
 303   tool No.         Sandvik    415 - Multi   CNMM   643 - 71    (4140: 24)
  03   Note-  All Feeds - Slight Sparking
 304   tool No.         Sandvik    435 - Multi   CNMM   643 - 71    (4140: 24)
  04   Note-  0.023" - Slight Sparking
 305   tool No.         Seco       TP20 - Multi  CNMG   643         (4130: 30)
  05   Note-  All Feeds - Slight Sparking, 0.027" - Nose Wear
 306   tool No.         Carboloy   560 - Multi   CNMG   543 - 69    (4130: 30)
  06   Note-  0.027" - Vibration & Sparking
 307   tool No.         Carboloy   560 - Multi   CNMG   643 - 68    (4130: 30)
  07   Note-  0.020" - Sparking
C34
C35
C36  INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C37  Finish and chip Qualities are indicated by the integer corresponding to
C38  catagories entered above. These are followed by the COEFFICIENT and POWER
C39  ( used in the tool-life, speed equation )  from the data for each test.
C40
C41  ALL of the above values will appear on each line of data entered and be
C42  READ from DO LOOPs structured as follows - -
C43
C44  For each INSERT -
C45        DEPTH 1
C46             Feed 1
C47             Feed 2
C48             ...
C49             Feed n  ( over the range of feeds input after line C17 above )
C50        DEPTH 2
C51             Feed 1
C52             Feed 2
C53             ...
C54             Feed n
C55      ....
C56        DEPTH m ( over the range of depths input after comment line C14 )
C57             Feed 1
C58             ...
C59  Skip a line ( or put in a comment line ) before each INSERT data set.
C60  Next INSERT
C61        DEPTH 1
C62              Feeds
C63              etc.
C64  Skip etc
C65
C66  Enter a zero if no data was taken for a particular DEPTH and FEED.
C67  Begin entrys after comment line  C72
C68  Put entrys in  7  positions of  10  spaces each as shown from C69 to C72.
C69      1         2         3         4         5         6         7
C70  67890123456789012345678901234567890123456789012345678901234567890123456789
```

```
C71 INSERT    DEPTH       FEED        FINISH      CHIP       COEF-      POWER
C72 INDEX     INDEX       INDEX       INDEX       INDEX      FICIENT    EXPONENT
C73
This line following comment line C72 is the SKIP line before first INSERT 301.
      301          1           1           2           1     2.5681        .14
      301          1           2           4           1     2.4871        .09
      301          1           3           5           1     2.4898        .18
skip
      302          1           1           2           3     2.7997        .20
      302          1           2           4           2     2.7606        .16
      302          1           3           5           1     2.6582        .14
skip
      303          1           1           2           2     2.7506        .13
      303          1           2           4           1     2.8759        .25
      303          1           3           5           1     2.7711        .21
skip
      304          1           1           2           2     2.6445        .21
      304          1           2           5           1     2.6045        .13
      304          1           3           4           1     2.6493        .27
skip
      305          1           1           4           1     2.9076        .29
      305          1           2           5           1     2.6774        .11
      305          1           3           5           1     2.6913        .15
skip
      306          1           1           2           1     2.7081        .07
      306          1           2           3           1     2.7082        .08
      306          1           3           5           1     2.6454        .11
skip
      307          1           1           2           1     2.7171        .04
      307          1           2           4           1     2.7016        .08
      307          1           3           5           1     2.6777        .09
```

Data File: R_DIA55DATA

```
C1      DIA55DATA( data file 8 for subroutine D_DIAMOND_55 called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5        The number of comment lines and their placement are fixed by program
C6        SORT.  However, the content may be altered or omitted.
C7
C8       INPUT the number of data entries in the order specified
C9       below.  These numbers MUST correspond to the number of
C10      entries for each category in this data file.
C11         NSERTS      NDEPTHS       NFEEDS       NFINISHS      NCHIPS
              4            1            3             6             3
C12     INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13     Enter NDEPTHS numbers in thousandths of an inch from the
C14     smallest INCREASING to the largest.
          200
C15     INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16     Enter NFEEDS numbers in thousandths of an inch from the
C17     smallest INCREASING to the largest.
          20        23        27
C18     INPUT FINISHes  ( obtained from test data )  after comment line C20
C19     Enter NFINISHS numbers in micro-inchs RMS  from the
C20     smallest INCREASING to the largest.
          180       250       330       375       500       600
C21     Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22     would like them to be outputted in the program.
C23     Place each SFINISH on a seperate line, starting with the smallest
C24     RMS to the largest RMS.  Each SFINISH is allowed 10 characters,
C25     starting in Column 11.
C26         1         2         3
C27  678901234567890123456789 0
               125+
               250
               250+
             250-500
               500
               500+
C28     INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29     Enter NCHIPS lines describing chip catagories used in data collection.
C30     Enter the BEST first, the WORST last.    Begin after comment line C30.
   1 - good,  all small chips,  no curls
   2 - fair,  70% small chips,  30% short curls
   3 - poor,  bird cage,  long curls,  etc.
C31     INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32     followed by NOTES on test observations   on a line  up to 80 spaces wide.
C33     Begin input of INSERT IDENTIFIER lines after this comment line C33.
    401    tool No. 50143       Sandvik 415 - Multi DNMG-543         (4130:29/30)
     01    Note-    All Feeds   -  Sparking and Some Nose Chipping
    402    tool No.             Valenite V05 - ALOX DNMG-542         (4130:29/30)
     02    Note-    All Feeds   -  Edge and Nose Chipping
    403    tool No              Kennametal 950 - Multi DNMG-543     (4130:29/30)
     03    Note 0.020"-Spking, 0.023"-Spking/Crater, 0.027"-Spking/Nose Chipping
    404    tool No              Carboloy 560 - Multi DNMG-543E-48  (4130:29/30)
     04    Note- 0.020"-Nose Wear, 0.023" and 0.027"-Sparking/Nose Chipping
```

```
C34
C35
C36   INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C37   Finish and chip Qualities are indicated by the integer corresponding to
C38   catagories entered above. These are followed by the COEFFICIENT and POWER
C39   ( used in the tool-life, speed equation )  from the data for each test.
C40
C41   ALL of the above values will appear on each line of data entered and be
C42   READ from DO LOOPs structured as follows - -
C43
C44   For each INSERT -
C45          DEPTH 1
C46                Feed 1
C47                Feed 2
C48                ...
C49                Feed n  ( over the range of feeds input after line C17 above )
C50          DEPTH 2
C51                Feed 1
C52                Feed 2
C53                ...
C54                Feed n
C55             ....
C56          DEPTH m ( over the range of depths input after comment line C14 )
C57                Feed 1
C58                ...
C59   Skip a line ( or put in a comment line ) before each INSERT data set.
C60   Next INSERT
C61          DEPTH 1
C62                 Feeds
C63                 etc.
C64   Skip etc
C65
C66   Enter a zero if no data was taken for a particular DEPTH and FEED.
C67   Begin entrys after comment line  C73
C68   Put entrys in  7  positions of  10  spaces each as shown from C69 to C72.
C69       1         2         3         4         5         6         7
C70  6789012345678901234567890123456789012345678901234567890123456789
C71 INSERT:  DEPTH   :   FEED   :  FINISH :   CHIP   :  COEF-  :  POWER   :
C72 INDEX :  INDEX   :  INDEX   :  INDEX   :  INDEX   : FICIENT : EXPONENT:
C73
This line following comment line C73 is the SKIP line before first INSERT 401.
       401         1         1         2         2    2.7433      .14
       401         1         2         4         2    2.7579      .15
       401         1         3         3         2    2.6689      .12
skip
       402         1         1         5         1    2.6047      .08
       402         1         2         5         2    2.6224      .12
       402         1         3         5         2    2.6876      .22
skip
       403         1         1         4         1    2.9276      .26
       403         1         2         5         1    2.6511      .07
       403         1         3         4         1    2.7067      .13
skip
       404         1         1         4         1    2.6395      .02
       404         1         2         3         2    2.6430      .07
       404         1         3         5         1    2.6139      .08
```

Data File: R_ROUDATA

```
C1      ROUDATA( data file 9 for subroutine ROUND called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5         The number of comment lines and their placement are fixed by program
C6         SORT.  However, the content may be altered or ommited.
C7
C8       INPUT the number of data entries in the order specified
C9       below.  These numbers MUST correspond to the number of
C10      entries for each category in this data file.
C11          NSERTS        NDEPTHS      NFEEDS      NFINISHS      NCHIPS
                4              1           4            6             3
C12     INPUT D.O.Cuts  ( used in tests to obtain data )  after comment line C14
C13     Enter NDEPTHS numbers in thousandths of an inch from the
C14     smallest INCREASING to the largest.
          200
C15     INPUT FEEDs  ( used in tests to obtain data )  after comment line C17
C16     Enter NFEEDS numbers in thousandths of an inch from the
C17     smallest INCREASING to the largest.
          20       23       27       30
C18     INPUT FINISHes  ( obtained from test data )  after comment line C20
C19     Enter NFINISHS numbers in micro-inchs RMS  from the
C20     smallest INCREASING to the largest.
          180      250      330      375      500      600
C21     Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22     would like them to be outputted in the program.
C23     Place each SFINISH on a seperate line, starting with the smallest
C24     RMS to the largest RMS.  Each SFINISH is allowed 10 characters,
C25     starting in Column 11.
C26        1        2        3
C27    678901234567890123456789 0
             125+
             250
             250+
           250-500
             500
             500+
C28     INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29     Enter NCHIPS lines describing chip catagories used in data collection.
C30     Enter the BEST first, the WORST last.    Begin after comment line C30.
  1 - good,  all small chips,  no curls
  2 - fair,  70% small chips,  30% short curls
  3 - poor,  bird cage,  long curls,  etc.
C31     INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32     followed by NOTES on test observations   on a line  up to 80 spaces wide.
C33     Begin input of INSERT IDENTIFIER lines after this comment line C33.
   501 Tool No. 51048 Kennametal 950 - Multi RNMG 64          (4130: 29/30)
    01 Note - 0.023' Edge Wear, 0.027' + 0.030' Edge Wear + Sparking
   502 Tool No.        VR/Wesson 680 - Multi RNMG 64          (4130: 29/30)
    02 Note - 0.023' Sparking, 0.027' + 0.030' Edge Wear + Sparking
   503 Tool No. 51049 Carboloy 570 - AlOX RNMG 64 - 48        (4130: 29/30)
    03 Note-0.023' EdgeWear+Sparking, 0.027' Sparking, .030' EdgeWear+Sparking
   504 Tool No. 51050 Valenite V05 - AlOX RNMG 64             (4130: 29/30)
    04 Note-0.023' Edge Wear + Sparking, 0.027' + 0.030' Edge Wear + Chipping
```

```
C34
C35
C36   INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
C37   Finish and chip Qualities are indicated by the integer corresponding to
C38   catagories entered above. These are followed by the COEFFICIENT and POWER
C39   ( used in the tool-life, speed equation )  from the data for each test.
C40
C41   ALL of the above values will appear on each line of data entered and be
C42   READ from DO LOOPs structured as follows - -
C43
C44   For each INSERT -
C45          DEPTH 1
C46                Feed 1
C47                Feed 2
C48                ...
C49                Feed n  ( over the range of feeds input after line C17 above )
C50          DEPTH 2
C51                Feed 1
C52                Feed 2
C53                ...
C54                Feed n
C55        ....
C56          DEPTH m ( over the range of depths input after comment line C14 )
C57                Feed 1
C58                ...
C59   Skip a line ( or put in a comment line ) before each INSERT data set.
C60   Next INSERT
C61          DEPTH 1
C62                 Feeds
C63                 etc.
C64   Skip etc
C65
C66   Enter a zero if no data was taken for a particular DEPTH and FEED.
C67   Begin entrys after comment line  C73
C68   Put entrys in  7  positions of  10  spaces each as shown from C69 to C72.
C69       1         2         3         4         5         6         7
C70   6789012345678901234567890123456789012345678901234567890123456789
C71 INSERT:  DEPTH   :   FEED   :  FINISH :   CHIP   :   COEF-  :  POWER   :
C72 INDEX :  INDEX   :  INDEX   :  INDEX   :  INDEX   : FICIENT : EXPONENT:
C73
This line following comment line C73 is the SKIP line before first INSERT 501.
      501         1         1         0         0         0         0
      501         1         2         1         1    3.0161       .26
      501         1         3         4         1    3.0735       .31
      501         1         4         4         1    2.8183       .14
skip
      502         1         1         0         0         0         0
      502         1         2         1         2    2.9370       .21
      502         1         3         4         1    2.6681       .05
      502         1         4         5         1    2.6751       .05
skip
      503         1         1         0         0         0         0
      503         1         2         3         2    2.9025       .17
      503         1         3         4         1    2.7513       .07
      503         1         4         5         1    2.7371       .07
skip
      504         1         1         0         0         0         0
      504         1         2         4         1    2.9249       .17
      504         1         3         5         1    2.7896       .10
      504         1         4         5         1    2.7017       .06
```

This page intentionally left blank.

APPENDIX C

FINISHING SIZE INSERTS

This page intentionally left blank.

MANUFACTURER AND GRADE, & ISO SYSTEM CLASS MULTICOATED	GEOMETRY	SIZE AND STYLE	FEED = 0.012 INCHES/REV				FEED = 0.017 INCHES/REV				FEED = [illegible] INCHES/REV				FEED = [illegible] INCHES/REV			
			V (SP) AT T = 10	CHIPS / RMS	IN³/MIN MRR AT T = 10	LOG CT / SLOPE	V (SP) AT T = 10	CHIPS / RMS	IN³/MIN MRR AT T = 10	LOG CT / SLOPE	V (SP) AT T = 10	CHIPS / RMS	IN³/MIN MRR AT T = 10	LOG CT / SLOPE	V (SP) AT T = 10	CHIPS / RMS	IN³/MIN MRR AT T = 10	LOG CT / SLOPE
KENNAMETAL 950, C6 C7	TNMG	433K	[illegible]	G / 63+	5.3	2.9486 / .16	592	G / 125	7.2	[illegible] / .15	[illegible]	G / 125+	[illegible]	2.859[illegible]				
	TNMM	433	658	P / 63+	5.7	2.9137	613	F / 125+	7.5	3.0345 / .2[illegible]	526	F / 250	7.6	2.987[illegible] / .2[illegible]				
	SNMM	432	598	F / 63+	5.2	2.9000 / .12	537	G / 125	6.6	3.0973 / .37	43[illegible]	G / 250	6.2	[illegible]				
	CNMS	432	562	G / 63+	4.9	2.8452	526	F-G / 125	6.4	2.9976 / .28	404	G / 125+	5.8	2.76[illegible]				
	RNMG	43					631	F / 63	7.[illegible]	[illegible]	549	F / 63	7.9	[illegible] / .16	593	[illegible] / 125	9.8	3.1[illegible]35 / .35
SECO TP15, C6 C7	TNMM	432.37	542	F / 125	4.7	2.8254 / .09	475	G / 125+	5.8	2.9286 / .25	44[illegible]	G / 125+	6.4	[illegible]				
	SNMM	432.37	550	F / 125	4.8	2.8653 / .12	404	G / 125+	4.9	2.9064 / .3[illegible]	376	G / 125+	5.4	2.[illegible]96 / .3				
	CNMM	432.37	501	G / 125	4.3	2.7764 / .08	380	G / 125	4.7	2.8183 / .24	3[illegible]	G / 250	4.5	2.626 / .14				
	DNMM	442.37	413	F / 125+	3.6	2.7649 / .15	284	G / 125+	3.5	2.6607 / .2[illegible]								
SECO TP10, C6 C8	TNMM	432.37	474	G / 63+	4.1	2.9077 / .23	416	G / 125	5.1	2.8468 / .23	410	G / 125+	5.9	2.823[illegible] / .2[illegible]				
	SNMM	432.37	595	F / 63	5.1	2.9553 / .18	537	F / 125	6.6	2.8955	475	P / 250	6.8	2.9344 / .26				
	CNMM	432.37	5[illegible]3	G / 63+	4.4	3.1542 / .44	433	F / 125+	5.3	2.8132 / .18	377	F / 250	5.4	2.8906 / .3				
	DNMM	442.37	340	G / 125	2.9	2.8252 / .29	296	F / 125+	3.6	2.6637 / .19								
CLEVELAND CV3, C5 C7	TNMP	432.4[illegible]	45[illegible]	G / 63+	3.9	2.8974 / .24	411	G / 125	5.0	2.8100 / .2[illegible]	297	G / 125+	4.3	2.66[illegible] / .2[illegible]				
	SNMG	432	499	G / 63	4.3	2.8526 / .15	425	G / 125+	5.2	2.7898 / .16	396	G / 125+	5.[illegible]	2.7256 / .13				
	CNMP	432.43	362	G / 63+	3.1	2.7744 / .22	283	G / 125+	3.5	2.7456 / .29	289	G / 250	4.2	2.[illegible]833 / .12				
	CNMG	432	412	P / 63+	3.6	2.8688 / .25	384	P / 125+	4.7	2.7164 / .13	350	F / 125+	5.0	2.6526				
SANDVIK GC415, C6 C8	TNMM	432.71	642	F / 63+	5.5	2.9758 / .17	503	G / 125	6.2	2.9258 / .22	452	G / 250	6.5	2.8366 / .18				
	SNMM	432.71	665	F / 63+	5.7	3.0576 / .23	582	G / 125	7.[illegible]	2.9056 / .14	517	G / 250+	7.4	2.9660 / .2[illegible]				
	CNMG	432.15	5[illegible]	G / 63+	4.4	2.880[illegible] / .17	430	G / 125+	5.3	2.9123 / .28	389	G / 250	5.6	2.724[illegible] / .13				
	DNMG	432.15	290	G / 125+	2.5	2.7[illegible] / .25	277	G / 125	3.4	2.6637 / .22	267	G / 250	3.8	2.6675 / .18				
	RNMG	43	652	P / 63	5.6	3.3378 / .52	612	P / 125	7.5	3.1120 / .33	552	F / 125+	7.9	3.0[illegible] / .3[illegible]	525	F / 125+	8.7	2.9316 / .21
SANDVIK GC435 C5	TNMM	433.71	672	P / 63+	5.8	3.1288 / .3[illegible]	562	F / 125+	6.9	3.0520 / .30	525	F / 250	7.6	2.917[illegible] / .22				
	CNMG	432.61	423	G / 63+	3.7	2.8463 / .22	352	G / 125+	4.3	2.6970 / .15	32[illegible]	G / 125+	4.6	2.6768				
V.R. WESSON 680 C7	TNMM	432	[illegible]36	P / 63+	5.5	2.8882 / .09	524	G / 125	6.4	2.865[illegible] / .09	438	G / 250	6.3	2.6[illegible] / .16				
	TNMG	432E	385	P / 63+	3.3	2.805[illegible] / .22	373	G / 125	4.6	2.8123 / .24	33[illegible]	G / 125+	4.8	[illegible] / .19				
	SNMG	432	569	G / 63+	4.9	2.9469 / .19	456	G / 125	5.6	2.9919 / .33	299	G / 125+	4.3	[illegible] / .16				
	CNMM	432E	55[illegible]	G / 63+	4.8	2.9019 / .16	46[illegible]	G / 125+	5.6	2.8547 / .19	344	G / 125+	5.2	2.7[illegible]				
	DNMG	432E	350	F / 63+	3.0	3.2334 / .69	309	G / 125	3.8	2.6427 / .15	223	F / 125+	3.[illegible]	2.66[illegible] / .2[illegible]				
	RNMG	43					546	F / 125	6.7	2.883[illegible] / .15	55[illegible]	G / 125+	7.9	[illegible] / .2[illegible]	[illegible]72	F / 125	9.6	2.7742 / .06
VALENITE VC[illegible]	CNGG	432	383	P / 63+	3.4	2.866[illegible]	[illegible]	[illegible]	4.[illegible]	2.8643 / [illegible]	26[illegible]	[illegible]	3.8	2.[illegible] / .3[illegible]				
UNCOATED C[illegible]																		
KENNAMETAL K68	TNMG	432	[illegible]	G / 63+	[illegible]	[illegible]	[illegible]	G / 125+	2.8	[illegible] / .4[illegible]	236	G / 250	3.4	[illegible] / .26				
[illegible] C2 C3	[illegible]	[illegible]		[illegible] / 63+	[illegible]	[illegible]	[illegible]	[illegible]	2.3	2.6461 / .38	[illegible]	G / [illegible]	2.2	2.[illegible]462				

MANUFACTURER AND GRADE, & [illegible] SYSTEM CLASS Al_2O_3 COATED	GEOMETRY	SIZE AND STYLE	FEED = 0.012 INCHES/REV				FEED = 0.017 INCHES/REV				FEED = 0.020 INCHES/REV				FEED = 0.023 INCHES/REV			
			V_{10} (SP AT T_L = 10')	CHIPS / RMS	IN3/MIN MRR AT T_L = 10	LOG OF INT / SLOPE	V_{10} (SP AT T_L = 10')	CHIPS / RMS	IN3/MIN MRR AT T_L = 10	LOG OF INT / SLOPE	V_{10} (SP AT T_L = 10')	CHIPS / RMS	IN3/MIN MRR AT T_L = 10	LOG OF INT / SLOPE	V_{10} (SP AT T_L = 10')	CHIPS / RMS	IN3/MIN MRR AT T_L = 10'	LOG OF INT / SLOPE
TRW 918, C6 C7	TNMG	432	508	F / 125	4.4	2.8574 / 15	460	G / 125+	5.6	3.0587 / 40	4[illegible]	G / 250	6.0	[illegible]9435 / 32				
	SNMG	432	531	F / 125	4.6	3.022[illegible] / 30	475	F / 125+	5.8	2.8656 / 19	438	G / 250	6.3	2.8508 / 2[illegible]				
	CNMG	432	497	P / 125	4.3	2.8948 / 20	427	F / 125	5.2	2.8024 / 17	369	G / 125+	5.3	[illegible]8233 / 26				
CARBOLOY 545, C8	TNMG	432-48	526	P / 125	4.5	2.8758 / 10	492	F / 125+	6.0	2.8439 / 1[illegible]	442	G / 250	6.4	[illegible] / 15				
	SNMM	432-52	690	P / 125	6.0	3.2531 / 41	514	P / 125	6.3	2.9439 / 23	468	P / 250	6.7	3.2065 / 54				
	CNMG	432-48	434	C / 63+	3.7	2.9009 / 26	379	[illegible] / 125	4.6	2.7412 / 16	314	G / [illegible]	4.5	2.6478 / 15				
	RNMG	43-48					672	F / 63	8.2	3.0840 / 26	564	F / 63	8.1	3.1638 / 41	591	G / 125	9.8	2.9326 / 16
CARBOLOY 570, C6 C7	TNMG	432-26	588	G / 125	5.1	3.3489 / 58	527	G / 125+	6.5	2.9397 / 22	446	G / 250	6.4	2.885[illegible] / 24				
	TNMP	432-16	645	G / 125	5.6	[illegible] / 35	551	G / 125+	6.7	3.[illegible]79 / 37	449	G / 250	6.5	3.[illegible]4 / 41				
	TNMM	432-52	682	P / 63+	5.9	3.[illegible]45[illegible] / 37	523	G / 125	6.4	2.891[illegible] / [illegible]	452	F / 250	6.5	3.074[illegible] / 42				
	DNMG	433-48	525	P / 125	4.5	3.0831 / 36	517	G / 125+	6.3	3.1062 / 39	420	G / 250	6.0	2.87[illegible] / 2[illegible]				
CLEVELAND CP1 C7 C8	TNMG	432	6[illegible]2	F / 63+	5.3	3.[illegible]64 / 23	545	F / 125+	6.[illegible]	2.9443 / 2[illegible]	484	G / 250+	7.0	2.8866 / 20				
	TNMP	432-41	567	G / 125+	4.9	3.0828 / 32	534	G / 250	6.5	2.94[illegible] / 2[illegible]	458	G / 250+	6.6	2.8839 / 22				
	SNMG	432	640	G / 63+	5.5	[illegible] / 36	542	G / 125+	6.6	2.9427 / 2[illegible]	493	G / 250	7.[illegible]	3.[illegible]155 / 32				
	CNMP	432-43	495	C / 63+	4.3	2.89[illegible] / 2[illegible]	475	G / 125+	5.[illegible]	2.9355 / 31	360	G / 125+	5.2	2.81[illegible] / 2[illegible]				
	CNMG	432	572	F / 63+	4.9	2.9366 / 18	475	F / 125+	5.[illegible]	2.8824 / 26	398	P / 125+	5.7	[illegible] / 14				
CARMET CA 7000 C7	TNMG	432E	531	F / 125	4.6	3.[illegible] / 39	473	F / 125+	5.8	2.9715 / 30	440	G / 125+	6.3	2.7608 / 12				
	SNMG	432E	598	F / 63+	5.2	3.1958 / 42	488	F / 125+	6.0	2.8394 / 15	4[illegible]7	G / 125+	6.0	2.959[illegible] / 34				
	CNMG	432E	465	P / 63+	4.[illegible]	2.7814 / 1[illegible]	377	F / 125	4.6	2.7[illegible]00 / 1[illegible]	[illegible]99	G / 250	2.9	2.5403 / 24				
	DNMG	432E	363	P / 63+	3.1	2.9107 / 15	332	F / 125+	4.1	2.8079 / 29	270	F / 25[illegible]	3.9	2.6755 / 24				
SANDVIK GC015 C7	TNMG	432-61	527	G / 125	4.6	2.9943 / 27	437	G / 125+	5.3	2.8562 / 22	434	G / 250+	6.2	2.7455 / [illegible]				
	CNMG	432-61	443	F / 63+	3.8	2.8533 / 2	3[illegible]7	G / 125+	4.6	2.8693 / 32	348	G / 250	5.0	2.793[illegible] / 2[illegible]				
FIRTH STERLING CC46, C7 C8	TNMG	432	591	P / 63+	5.1	2.9676 / 20	527	G / 125+	6.5	3.0622 / 34	458	G / 250	6.6	2.896[illegible] / 44				
	SNMG	432	527	F / 125	4.6	2.8141 / 09	515	G / 125	6.3	2.9402 / 23	464	G / 250	6.7	2.8595 / 20				
	CNMG	432	57[illegible]	P / 63+	4.9	2.905[illegible] / 15	419	G / 125	5.1	2.9198 / 30	338	G / 125+	4.9	2.6719 / 14				
		4[illegible]	[illegible]13	P / 125+	4.7	2.9049 / 17	361	G / 125+	4.4	2.7776 / [illegible]	31[illegible]	G / 125+	4.5	2.7730 / 28				
VALENITE VO1 C7 C8	TNMM	432ER	448	P / 63+	3.9	2.7959 / 14	502	P / 125	6.1	2.931[illegible] / 23	436	P / 250	6.3	2.9[illegible]63 / 28				
	TNMM	432F FF	520	F / 125	4.5	2.9742 / 25	451	G / 125+	5.5	2.8000 / 15	361	G / 250	5.2	2.8255 / 27				
	DNMG	433	524	P / 125+	4.5	2.8940 / 1[illegible]	405	P / 125+	5.0	2.8252 / 22	384	F / 125+	5.5	2.9174 / 33				
	RNMG	[illegible]					650	P / 63	8.0	3.[illegible]063 / 29	536	F / 63	7.[illegible]	3.0249 / 30	633	F / 125+	10.5	3.2212 / 42
VALENITE VO5, C5 C7	TNMG	433	608	F / 125	5.3	2.9884 / 20	475	G / 125	5.8	2.8454 / 17	415	G / 125+	6.0	2.7643 / 15				
	SNMG	432	543	G / 125	4.[illegible]	2.9[illegible] / 18	541	G / 125	6.6	2.8823 / 15	438	G / 250+	6.3	2.9044 / 26				
	CNMG	432	438	F / 63+	3.8	2.8623 / 16	374	F / 125	4.6	2.7398 / 17	33[illegible]	F / 125+	4.0	2.7186 / 19				
	RNMG	43					620	P / 125	7.6	2.9982 / 2[illegible]	593	F / 125+	8.5	[illegible] / [illegible]	500	F / 125+	8.3	2.9140 / 22
[illegible]	RNMG	4[illegible]	[illegible]	P / 63	5.6	3.[illegible] / [illegible]	588	P / 125	7.2	3.0230 / 25	585	P / 125	8.4	3.[illegible] / 26	575	P / 125+	8.5	2.9935 / 28
[illegible] C7	TNMG	4[illegible]	[illegible]	F / 63+	4.5	2.86[illegible] / [illegible]	476	G / 125+	5.1	2.8981 / 28	393	G / 125+	5.7	2.97[illegible] / 18				
	CNMG	4[illegible]	46[illegible]	F / 63+	4.0	[illegible] / 14	379	G / [illegible]	4.6	2.8128 / [illegible]	3[illegible]	G / 125+	4.5	2.7[illegible] / 22				
	DNMG	[illegible]	[illegible]	P / 63+	4.2	[illegible] / 2[illegible]	384	P / [illegible]	4.8	2.8[illegible] / 2[illegible]	[illegible]	G / 125+	5.2	2.8026 / [illegible]				

APPENDIX D

ROUGHING SIZE INSERTS

This page intentionally left blank.

MANUFACTURER AND GRADE & "C" SYSTEM CLASS	GEOMETRY	SIZE AND STYLE	FEED = 0.020 INCHES/REV				FEED = 0.02[illegible] INCHES/REV				FEED = [illegible] INCHES/REV				FEED = [illegible] INCHES/REV			
MULTICOATED			V10 (SFPM AT T = 10)	CHIPS / RMS	INT MIN MRR AT T = 10	LOG OF INT / SLOPE	V10 (SFPM AT T = 10)	CHIPS / RMS	INT MIN MRR AT T = 10	LOG OF INT / SLOPE	V10 (SFPM AT T = 10)	CHIPS / RMS	INT MIN MRR AT T = 10	LOG OF INT / SLOPE	V10 (SFPM AT T = 10)	CHIPS / RMS	INT MIN MRR AT T = 10	LOG OF INT / SLOPE
KENNAMETAL 950 C6-C7	TNMM	543	470	P / 250+	22.6	2.8616 / -0.19	442	G / 250-500	24.4	2.8394 / -0.19	398	F / 250-500	25.8	2.822[illegible] / -0.22				
	ONMG	543	467	G / 250-500	22.4	2.9276 / 0.26	383	G / 500	21.1	2.6511 / -0.07	375	G / 250-500	24.3	[illegible]				
	RNMG	64	—			—	574	G / 125-250	31.7	3.0161 / -0.26	580	G / 250-500	37.6	[illegible]	482	G / [illegible]	34.7	[illegible]
SANDVIK 415 C6-C8	SNMM	643-71	342	G / 250	16.4	2.6318 / -0.09	326	G / 250	18.0	2.7149 / [illegible]	308	G / 250	20.0	[illegible]				
	CNMM	643-71	420	F / 250	20.2	2.7506 / -0.13	427	G / 250-500	23.6	2.8159 / -0.25	362	G / 500	23.5	[illegible]				
	DNMG	543-15	400	F / 250	19.2	2.7411 / -0.14	403	F / 250-500	22.2	2.7519 / -0.15	355	F / 250+	23.0	2.6649 / -0.12				
SANDVIK 435 C5	TNMM	543-71	366	F / 250	17.6	2.7120 / -0.15	372	G / 250-500	20.5	2.6803 / -0.13	284	G / 500	18.4	2.6456 / -0.19				
	SNMM	643-71	351	F / 250-500	16.8	2.6494 / -0.10	301	G / 250+	16.6	2.5757 / 0.10	299	G / 500	19.4	2.5985 / -0.12				
	CNMM	643-71	272	F / 250	13.1	2.6445 / 0.21	299	G / 500	16.5	2.6045 / -0.13	238	G / 250-500	15.4	2.6491 / [illegible]				
SECO TP15 C6-C7	SNMM	643-37	352	F / 250+	16.9	2.7127 / 0.17	336	G / 250-500	18.5	2.6159 / 0.09	315	G / 250-500	20.4	2.6304 / -0.13				
SECO TP20 C6-C7	CNMG	643	416	G / 250-500	20.0	2.9076 / 0.29	373	G / 500	20.6	2.6774 / -0.11	352	G / 500	22.8	2.6913 / -0.15				
VR/WESSON 680 C6-C8	RNMG	64	—				529	F / 125	29.2	2.9370 / 0.21	411	G / 250-500	26.6	2.6681 / [illegible]	426	G / 500	30.7	2.6751 / -0.05
WIDALON TK15 C6-C8	TNMM	543-6	442	G / 250	21.2	2.7645 / -0.14	437	G / 250	24.1	2.7855 / -0.15	360	G / 250-500	23.3	2.8787 / -0.26				
	SNMM	643-6	452	P / 250	[illegible]	2.7451 / -0.09	433	F / 250-500	23.9	2.8663 / 0.23	383	G / 500	24.8	2.7120 / -0.11				
CARBOLOY 560 C6-C7	CNMG	543E-68	438	G / 250	21.0	2.7081 / -0.17	426	[illegible] / 250+	23.5	2.7082 / -0.08	346	G / 500	22.4	2.6454 / -0.11				
	CNMG	643-68	477	G / 250	22.9	[illegible] / -0.04	420	G / 250-500	23.2	2.7016 / -0.08	383	G / 500	24.8	[illegible] / -0.09				
	DNMG	543E-48	413	G / 250-500	19.8	2.6195 / -0.02	377	F-G / 250+	20.8	2.6430 / -0.07	340	G / 500	22.0	2.6319 / -0.08				
Al_2O_3 COATED																		
CARBOLOY 570 C6-C7	TNMM	543-85	433	P / 250	20.8	2.8145 / -0.18	426	P / 250-500	23.5	2.8272 / -0.19	397	F / 250-500	25.7	2.8465 / -0.25				
	RNMG	64-48					538	F / 250+	29.6	2.9625 / -0.17	477	G / 250-500	30.9	2.7511 / -0.07	458	G / [illegible]	33.0	[illegible]
TRW 955 C5	CNMG	643E	266	G / 250+	12.7	2.5681 / -0.14	251	G / 250-500	13.9	2.4875 / [illegible]	205	G / 500	13.3	2.4498 / -0.18				
TRW 9[illegible]8 C6-C7	TNMG	543E	424	F / 250	20.4	2.6961 / -0.17	405	G / 250-500	22.4	2.6469 / -0.24	370	G / 500	24.0	2.7013 / -0.13				
	CNMG	643 CF1	396	P / [illegible]	19.0	[illegible]	396	F / 250-500	21.9	2.7616 / -0.16	329	G / 500	21.3	2.6582 / -0.14				
VALENITE VC5 C5-C7	TNMG	543	544	G / 250-500	26.1	[illegible]	511	G / 250-500	28.2	2.8943 / -0.19	392	G / 500	25.4	2.6407 / -0.05				
	TNMM	543[illegible]	461	F / 250	22.1	[illegible]	425	P / 250-500	23.5	2.6789 / [illegible]	402	G / 500	26.1	2.6839 / 0.08				
	DNMG	542	342	G / 500	16.4	2.604 / [illegible]	323	F-G / [illegible]	17.7	[illegible]	291	F-G / 500	19.0	[illegible] / -0.22				
	RNMG	64					558	G / 250-500	30.8	2.9243 / [illegible]	492	G / 500	31.9	2.7896 / 0.10	436	G / 500	31.4	2.7017 / -0.06
SANDVIK S6	SNMG	644	237	G / [illegible]	13.3	2.4983 / [illegible]	229	G / 250+	12.6	2.5422 / -0.18	229	G / 500	14.8	2.5787 / -0.22				
(UNCOATED C5)																		

This page intentionally left blank.

APPENDIX E

MACHINING DATA PROGRAM FOR FINISHING/ROUGHING SIZE
COATED CARBIDE CUTTING INSERTS USED IN TURNING OPERATIONS

This page intentionally left blank.

MACHINING DATA PROGRAM

FOR

FINISHING / ROUGHING SIZE

COATED CARBIDE CUTTING INSERTS

USED IN

TURNING OPERATIONS

Revision
Jul, 1986

prepared
by

Materials Science Division
Engineering Directorate
Rock Island Arsenal
Rock Island, Illinois 61299-5000

Dr. J. Moriarty
Dr. W. Brewer
M. Crosheck

MACHINING DATA PROGRAM

FOR

FINISHING / ROUGHING SIZE

COATED CARBIDE CUTTING INSERTS

USED IN

TURNING OPERATIONS

HIT RETURN TO CONTINUE

EXPERIMENTAL

EQUIPMENT -- Single point turning using a 30/60 horsepower turret lathe

CUTTING CONDITION -- Dry cutting only with fluid cooled workpiece

WORKPIECE MATERIAL-- AISI 4140 steel, hot rolled tubing for finishing inserts.
Heat treated, Quenched and Tempered to HRC 31 - 33
AISI 4140 & 4130 steel, hot rolled tubing for roughing inserts.
Heat treated, Quenched and Tempered to HRC 32 - 35 and 29/30 res

TOOL MATERIALS -- CVD coated carbide inserts
ALOX : ALOX exterior coating with TiC coat at substrate interface
Multi : TiN exterior coating with ALOX coat intermediate, and TiC or TaC coat at substrate interface

TOOL HOLDERS -- Negative 5 degree back rake and side rake angles with SCEA ranging from + 15 degrees to -3 degrees depending on shape of insert

ENTER RETURN TO CONTINUE

TOOL INSERT SIZE -- IC = 1/2 in. for finishing cut, DOC = 0.060 in.
IC = 5/8 in. or 3/4 in. for roughing cut, DOC = 0.200 in.

TOOL WEAR CRITERIA -- Finishing flank wear limits - 0.010" ave, or 0.020" max.
Roughing flank wear limits - 0.015" ave, or 0.030" max.

MEASURING PROCEDURE -- Tool flank wear was measured at predetermined time intervals (min.) until wear limit was reached

PERFORMANCE -- Tool life (min.) was recorded when the flank wear limit was reached, and the quality of chip control/form were judged and given a good, fair, or poor rating.

Workpiece surface finishes were assigned RMS(micro-inch) values by visual/tactual comparisons using a Std. Ordnance Finishes Set No. 10.

Wear mode patterns and occurance frequency were recorded per insert, as was the calculation of metal removal rate.

ENTER RETURN TO CONTINUE

Select Size of Insert to be Used:

1 Finishing (IC = 1/2 in.)
2 Roughing (IC = 5/8 in. OR 3/4 in.)

E Exit from the Program

1

Select Insert Shape

1 triangular
2 square
3 diamond 80 degree
4 diamond 55 degree
5 round

E Exit from the program.

3

Program will search DATA for the 18 DIAMOND(80 DEG) inserts tested.

301	tool No. 50743	TRW -	918 - Al Ox	CNMG	432	
302	tool No.	Carboloy -	545 - Al Ox	CNMG	432	- 48
303	tool No. 50741	Cleveland -	CP1 - Al Ox	CNMP	432	- 43
304	tool No.	Cleveland -	CP1 - Al Ox	CNMG	432	
305	tool No.	Carmet -	7000 - Al Ox	CNMG	432	- E
306	tool No. 50129	Sandvik -	015 - Al Ox	CNMG	432	- 61
307	tool No. 50742	Firth Sterling	CC46- Al Ox	CNMG	432	
308	tool No.	Valenite -	V05 - Al Ox	CNMG	432	
309	tool No.	Newcomer -	NA02 - Al Ox	CNMG	432	
310	tool No. 50009	Kennametal -	950 - Multi	CNMS	432	
311	tool No.	Seco -	TP10 - Multi	CNMM	432	- 37
312	tool No.	Seco -	TP15 - Multi	CNMM	432	- 37
313	tool No.	Cleveland -	CM3 - Multi	CNMP	432	- 43
314	tool No.	Cleveland -	CM3 - Multi	CNMG	432	
315	tool No. 50127	Sandvik -	415 - Multi	CNMG	432	- 15

Enter any key to continue .

316	tool No.	Sandvik -	435 - Multi	CNMG	432	- 61
317	tool No. 50740	VR/Wesson -	680 - Multi	CNMM	432	- E
318	tool No.	Valenite -	VC7 - Uncoated	CNGG -	432	

Enter any key to continue .

Choose FIRST Priority

F surface Finish

Q chip Quality

F

Priority 1 - surface Finish

Type in surface Finish you must have in

micro-inchs RMS

125

You asked for a 125. micro-inch finish.

Surface Finish data from test results that are closest to your specification are :

125 micro-inches RMS (compared to 125 RMS)

All results that follow will be based on this value.

Priority 2

Specify lowest chip Quality you can live with.

1 - good, all small chips, no curls
2 - fair, 70% small chips, 30% short curls
3 - poor, bird cage, long curls, etc.

2

Only data for which chip Quality equals or exceeds

2 - fair, 70% small chips, 30% short curls

will be considered.

Type the Depth Of Cut you want in

thousandths of an inch.

(Finishing - DOC = 0.060" : Roughing - 0.200")

60

You asked for a 0.060 inch Depth Of Cut.

The DEPTH for which test results are available that is closest to your request is

0.060 inch

All results that follow will be based on this value.

Choose Feed OPTION

1 User SPECIFIED Feed

2 All available Feed DATA that satisfy surface Finish & chip Quality criteria will be considered.

1

Feed Option 1 - User Specified Feed

Type the FEED you want in

thousandths of an inch / rev.

17

You asked for a 0.017 inch / rev. Feed.

The FEED for which test results are available that is closest to your request is

0.017 inch / rev.

All results that follow will be based on this value.

Choose Tool Life OPTION.

1 user specifies Tool Life
2 user specifies Length Of Cut
3 user specifies Surface Speed
4 optimize tool life for Lowest Cost
5 optimize tool life for Maximum Output

Note: Results are most reliable in the Tool Life range from 5 to 25 minutes.
Computations are limited to this range.

3

Would you like the Cost($) per cubic inch given in the output?
(Y/N)

Y

Type the Diameter Of Workpiece in

inches.

6

Type the Surface Speed you need in

surface feet per minute

500

Type the Time allowed to Change Inserts in

minutes

1

Type apporoximate Cost per Edge for inserts in

dollars / edge

2

Type the Labor plus Overhead rate in

dollars / hour

60

9 Insert - Feed combinations satisfy your specifications.

They will be listed according to their ,

Metal Removal Rates.

The first will have the highest MRR .

decreasing to the last.

Enter any key to see the 1st PAGE of INSERTS.

307	tool No.	50742	Firth Sterling	CC46	- Al Ox	CNMG	432
310	tool No.	50009	Kennametal -	950	- Multi	CNMG	432
301	tool No.	50743	TRW -	318	- Al Ox	CNMG	432
309	tool No.		Newcomer -	NA02	- Al Ox	CNMG	432
312	tool No.		Seco -	TP15	- Multi	CNMM	432 - 37
302	tool No.		Carboloy -	545	- Al Ox	CNMG	432 - 48
318	tool No.		Valenite -	VC7	- Uncoated	CNGG	- 432
308	tool No.		Valenite -	V05	- Al Ox	CNMG	432
305	tool No.		Carmet -	7000	- Al Ox	CNMG	432 - E

Enter "R" to Return to Option Menu. Enter any other key to continue.
ENTER # OF OPTION WANTED:

1 to look at Output of an Individual Insert

2 to see All inserts in order of highest MRR

3 to see the List of sorted Inserts

4 to see list of originally Inputted parameters

5 to see Definitions of terms used in line of NOTES on output

6 to Return to Option Menu

307 tool No. 50742 Firth Sterling CC46- Al Ox CNMG 432
07 Note- 0.012" - Nose Notch, 0.017" - Slight Notching
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.4 minutes
Surface Speed= 500. surface feet / minute
M. R. Rate = 6.1 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 29. inches
R. P. M. = 318. rev. / minute
Cost = $ 0.19 per cubic inch

Computations for user specified Depth Of Cut and Feed .
D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 6.1 cubic inches / minute
L. O. Cut = 29. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

310 tool No. 50009 Kennametal - 950 - Multi CNMS 432
10 Note- 0.012" - Slight Nose Notch, 0.017" - Slight Sparking
Chip Quality = 2 - fair, 70% small chips, 30% short curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 11.7 minutes
Surface Speed= 500. surface feet / minute
M. R. Rate = 6.1 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 63. inches
R. P. M. = 318. rev. / minute
Cost = $ 0.18 per cubic inch

Computations for user specified Depth Of Cut and Feed .
D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 6.1 cubic inches / minute
L. O. Cut = 63. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

301 tool No. 50743 TRW - 918 - Al Ox CNMG 432
01 Note- 0.012" - Notch, 0.017" - Slight Notching
Chip Quality = 2 - fair, 70% small chips, 30% short curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 483. surface feet / minute
M. R. Rate = 5.9 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 26. inches
R. P. M. = 307. rev. / minute
Cost = $ 0.20 per cubic inch

Computations for user specified Depth Of Cut and Feed .
D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.9 cubic inches / minute
L. O. Cut = 26. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

309 tool No. Newcomer - NA02 - Al Ox CNMG 432
09 Note- 0.017" - Slight Notch, 0.017" - Nose Wear
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 463. surface feet / minute
M. R. Rate = 5.7 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 25. inches
R. P. M. = 298. rev. / minute
Cost = $ 0.21 per cubic inch

Computations for user specified Depth Of Cut and Feed .
D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.7 cubic inches / minute
L. O. Cut = 25. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

312 tool No. Seco - TP15 - Multi CNMM 432 - 37
12 Note- 0.017" - CE Cratering & Slight Notch
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 447. surface feet / minute
M. R. Rate = 5.5 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 24. inches
R. P. M. = 285. rev. / minute
Cost = $ 0.22 per cubic inch

Computations for user specified Depth Of Cut and Feed .
D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.5 cubic inches / minute
L. O. Cut = 24. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

302 tool No. Carboloy - 545 - Al Ox CNMG 432 - 48
02 Note- 0.017" - Sparking, 0.017" - Slight Cratering
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 426. surface feet / minute
M. R. Rate = 5.2 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 23. inches
R. P. M. = 271. rev. / minute
Cost = $ 0.23 per cubic inch

Computations for user specified Depth Of Cut and Feed .
D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.2 cubic inches / minute
L O. Cut = 23. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

```
318  tool No.          Valenite -    VC7 - Uncoated CNGG - 432
 18  Note - 0.012" - Slight Sparking
  Chip Quality =    2 - fair,  70% small chips,  30% short curls

                Surf. Finish =     125    micro - inches
                     Depth of Cut =    0.060  inch
                     Feed         =    0.017  inch / rev.
                Tool Life    =      5.0 minutes
                Surface Speed=     422. surface feet / minute
                M. R. Rate   =      5.2 cubic inches / minute
                     D. O. Workpc =      6.0 inches
                     L. O. Cut    =      23. inches
                R. P. M.     =     269. rev. / minute
                Cost         =  $  0.23 per cubic inch

      Computations for user specified Depth Of Cut  and  Feed .
                     D. O. Cut    =    0.060  inch
                     Feed         =    0.017  inch / rev.
                M. R. Rate   =      5.2 cubic inches / minute
                L. O. Cut    =      23. inches

 Enter "R" to Return to Option Menu.  Enter any other key to continue.

308  tool No.          Valenite -    V05 - Al Ox   CNMG   432
 08  Note- 0.012" - Slight Notch, 0.017" - Slight Sparking
  Chip Quality =    2 - fair,  70% small chips,  30% short curls

                Surf. Finish =     125    micro - inches
                     Depth of Cut =    0.060  inch
                     Feed         =    0.017  inch / rev.
                Tool Life    =      5.0 minutes
                Surface Speed=     418. surface feet / minute
                M. R. Rate   =      5.1 cubic inches / minute
                     D. O. Workpc =      6.0 inches
                     L. O. Cut    =      23. inches
                R. P. M.     =     266. rev. / minute
                Cost         =  $  0.24 per cubic inch

      Computations for user specified Depth Of Cut  and  Feed .
                     D. O. Cut    =    0.060  inch
                     Feed         =    0.017  inch / rev.
                M. R. Rate   =      5.1 cubic inches / minute
                L. O. Cut    =      23. inches

 Enter "R" to Return to Option Menu.  Enter any other key to continue.
```

305 tool No. Carmet - 7000 - Al Ox CNMG 432 - E
05 Note- 0.017" - Slight Sparking
Chip Quality = 2 - fair, 70% small chips, 30% short curls

Surf. Finish	=	125 micro - inches
Depth of Cut	=	0.060 inch
Feed	=	0.017 inch / rev.
Tool Life	=	5.0 minutes
Surface Speed	=	416. surface feet / minute
M. R. Rate	=	5.1 cubic inches / minute
D. O. Workpc	=	6.0 inches
L. O. Cut	=	23. inches
R. P. M.	=	265. rev. / minute
Cost	=	$ 0.24 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut	=	0.060 inch
Feed	=	0.017 inch / rev.
M. R. Rate	=	5.1 cubic inches / minute
L. O. Cut	=	23. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

Re-enter program at Options for :

1 Shape of Insert (the beginning)
2 Finish and Chip priority
3 Feed
4 Tool Life / Length of Cut
5 Repeat of Results

Exit enter any other key

This page intentionally left blank.

MACHINING DATA PROGRAM

FOR

FINISHING / ROUGHING SIZE

COATED CARBIDE CUTTING INSERTS

USED IN

TURNING OPERATIONS

HIT RETURN TO CONTINUE

EXPERIMENTAL

EQUIPMENT -- Single point turning using a 30/60 horsepower turret lathe

CUTTING CONDITION -- Dry cutting only with fluid cooled workpiece

WORKPIECE MATERIAL-- AISI 4140 steel, hot rolled tubing for finishing inserts.
Heat treated, Quenched and Tempered to HRC 31 - 33
AISI 4140 & 4130 steel, hot rolled tubing for roughing inserts.
Heat treated, Quenched and Tempered to HRC 32 - 35 and 29/30 res

TOOL MATERIALS -- CVD coated carbide inserts
ALOX : ALOX exterior coating with TiC coat at substrate interface
Multi : TiN exterior coating with ALOX coat intermediate, and TiC or TaC coat at substrate interface

TOOL HOLDERS -- Negative 5 degree back rake and side rake angles with SCEA ranging from + 15 degrees to -3 degrees depending on shape of insert

ENTER RETURN TO CONTINUE

TOOL INSERT SIZE -- IC = 1/2 in. for finishing cut, DOC = 0.060 in.
IC = 5/8 in. or 3/4 in. for roughing cut, DOC = 0.200 in.

TOOL WEAR CRITERIA -- Finishing flank wear limits - 0.010" ave, or 0.020" max.
Roughing flank wear limits - 0.015" ave, or 0.030" max.

MEASURING PROCEDURE -- Tool flank wear was measured at predetermined time intervals (min.) until wear limit was reached

PERFORMANCE -- Tool life (min.) was recorded when the flank wear limit was reached, and the quality of chip control/form were judged and given a good, fair, or poor rating.

Workpiece surface finishes were assigned RMS(micro-inch) values by visual/tactual comparisons using a Std. Ordnance Finishes Set No. 10.

Wear mode patterns and occurance frequency were recorded per insert, as was the calculation of metal removal rate.

ENTER ¼RETURN½ TO CONTINUE

Select Size of Insert to be Used:

1 Finishing (IC = 1/2 in.)
2 Roughing (IC = 5/8 in. OR 3/4 in.)

E Exit from the Program

2

Select Insert Shape

1 triangular
2 square
3 diamond 80 degree
4 diamond 55 degree
5 round

E Exit from the program.

2

Program will search DATA for the 5 SQUARE inserts tested.

201	tool No. 50086	Sandvik	415 - Multi	SNMM	643 - 71	(4140: 34)
202	tool No.	Sandvik	435 - Multi	SNMM	643 - 71	(4140: 34)
203	tool No. 51046	Seco	TP15 - Multi	SNMM	643 - 37	(4140: 34)
204	tool No.	Widalon	TK15 - Multi	SNMM	643 - 6	(4140: 34)
205	tool No. 50082	Sandvik	S6 - Uncoat	SNMG	644	(4140: 34)

Enter any key to continue .

Choose FIRST Priority

F surface Finish

Q chip Quality

F

Priority 1 - surface Finish

Type in surface Finish you must have in

micro-inchs RMS

500

You asked for a 500. micro-inch finish.

Surface Finish data from test results that are closest to your specification are :

500 micro-inches RMS (compared to 500 RMS)

All results that follow will be based on this value.

Priority 2

Specify lowest chip Quality you can live with.
1 - good, all small chips, no curls
2 - fair, 70% small chips, 30% short curls
3 - poor, bird cage, long curls, etc.

2

Only data for which chip Quality equals or exceeds

2 - fair, 70% small chips, 30% short curls

will be considered.

Type the Depth Of Cut you want in

thousandths of an inch.

(Finishing - DOC = 0.060" : Roughing - 0.200")

200

You asked for a 0.200 inch Depth Of Cut.

The DEPTH for which test results are available that is closest to your request is

0.200 inch

All results that follow will be based on this value.

Choose Feed OPTION

1 User SPECIFIED Feed

2 All available Feed DATA that satisfy surface Finish & chip Quality criteria will be considered.

1

Feed Option 1 - User Specified Feed

Type the FEED you want in

thousandths of an inch / rev.

23

You asked for a 0.023 inch / rev. Feed.

The FEED for which test results are available
that is closest to your request is

0.023 inch / rev.

All results that follow will be based on this value.

Choose Tool Life OPTION.

1 user specifies Tool Life
2 user specifies Length Of Cut
3 user specifies Surface Speed
4 optimize tool life for Lowest Cost
5 optimize tool life for Maximum Output

Note: Results are most reliable in the Tool Life range from
5 to 25 minutes.
Computations are limited to this range.

3

Would you like the Cost($) per cubic inch given in the output?
(Y/N)

Y

Type the Diameter Of Workpiece in

inches.

6

Type the Surface Speed you need in

surface feet per minute

400

Type the Time allowed to Change Inserts in

minutes

1

Type apporoximate Cost per Edge for inserts in

dollars / edge

2

Type the Labor plus Overhead rate in

dollars / hour

60

5 Insert - Feed combinations satisfy your specifications.

They will be listed according to their ,

Metal Removal Rates.

The first will have the highest MRR .

decreasing to the last.

Enter any key to see the 1st PAGE of INSERTS.

204	tool No.	Widalon TK15	- Multi	SNMM	643 - 6	(4140: 34)
201	tool No. 50086	Sandvik 415	- Multi	SNMM	643 - 71	(4140: 34)
203	tool No. 51046	Seco TP15	- Multi	SNMM	643 - 37	(4140: 34)
202	tool No.	Sandvik 435	- Multi	SNMM	643 - 71	(4140: 34)
205	tool No. 50082	Sandvik 36	- Uncoat	SNMG	644	(4140: 34)

Enter "R" to Return to Option Menu. Enter any other key to continue.

ENTER # OF OPTION WANTED:

1 to look at Output of an Individual Insert

2 to see All inserts in order of highest MRR

3 to see the List of sorted inserts

4 to see list of originally Inputted parameters

5 to see Definitions of terms used in line of NOTES on output

6 to Return to Option Menu

2

```
204   tool No.        Widalon TK15 - Multi   SNMM   643 - 6    (4140: 34)
 04   Note-
 Chip Quality =    2 - fair,  70% small chips,  30% short curls

              Surf. Finish =   250-500  micro - inches
                   Depth of Cut =    0.200  inch
                   Feed         =    0.023  inch / rev.
              Tool Life     =     14.1 minutes
              Surface Speed=     400. surface feet / minute
              M. R. Rate    =     22.1 cubic inches / minute
                   D. O. Workpc =       6.0 inches
                   L. O. Cut    =       83. inches
              R. P. M.      =     255. rev. / minute
              Cost          = $   0.05 per cubic inch

      Computations for user specified Depth Of Cut  and  Feed .
                   D. O. Cut    =    0.200  inch
                   Feed         =    0.023  inch / rev.
              M. R. Rate    =     22.1 cubic inches / minute
              L. O. Cut     =      83. inches

 Enter "R" to Return to Option Menu.   Enter any other key to continue.

201   tool No. 50086   Sandvik  415 - Multi   SNMM   643 - 71   (4140: 34)
 01   Note-  All Feeds - Sparking, > 0.023" - Nose Def.
 Chip Quality =    1 - good,  all small chips,  no curls

              Surf. Finish =    250    micro - inches
                   Depth of Cut =    0.200  inch
                   Feed         =    0.023  inch / rev.
              Tool Life     =      5.0 minutes
              Surface Speed=     376. surface feet / minute
              M. R. Rate    =     20.8 cubic inches / minute
                   D. O. Workpc =       6.0 inches
                   L. O. Cut    =       28. inches
              R. P. M.      =     239. rev. / minute
              Cost          = $   0.06 per cubic inch

      Computations for user specified Depth Of Cut  and  Feed .
                   D. O. Cut    =    0.200  inch
                   Feed         =    0.023  inch / rev.
              M. R. Rate    =     20.8 cubic inches / minute
              L. O. Cut     =      28. inches

 Enter "R" to Return to Option Menu.   Enter any other key to continue.
```

203 tool No. 51046 Seco TP15 - Multi SNMM 643 - 37 (4140: 34)
03 Note- < 0.023" - End Sparking, 0.027" - Screeching
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 250-500 micro - inches
Depth of Cut = 0.200 inch
Feed = 0.023 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 357. surface feet / minute
M. R. Rate = 19.7 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 26. inches
R. P. M. = 227. rev. / minute
Cost = $ 0.06 per cubic inch

Computations for user specified Depth Of Cut and Feed .
D. O. Cut = 0.200 inch
Feed = 0.023 inch / rev.
M. R. Rate = 19.7 cubic inches / minute
L. O. Cut = 26. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

202 tool No. Sandvik 435 - Multi SNMM 643 - 71 (4140: 34)
02 Note-
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 250+ micro - inches
Depth of Cut = 0.200 inch
Feed = 0.023 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 320. surface feet / minute
M. R. Rate = 17.7 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 23. inches
R. P. M. = 204. rev. / minute
Cost = $ 0.07 per cubic inch

Computations for user specified Depth Of Cut and Feed .
D. O. Cut = 0.200 inch
Feed = 0.023 inch / rev.
M. R. Rate = 17.7 cubic inches / minute
L. O. Cut = 23. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

205 tool No. 50082 Sandvik S6 - Uncoat SNMG 644 (4140: 34)
05 Note- 0.020" + 0.023" -Sparking/Screeching, 0.027" -Cratering
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish	=	250+ micro - inches
Depth of Cut	=	0.200 inch
Feed	=	0.023 inch / rev.
Tool Life	=	5.0 minutes
Surface Speed	=	261. surface feet / minute
M. R. Rate	=	14.4 cubic inches / minute
D. O. Workpc	=	6.0 inches
L. O. Cut	=	19. inches
R. P. M.	=	166. rev. / minute
Cost	=	$ 0.08 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut	=	0.200 inch
Feed	=	0.023 inch / rev.
M. R. Rate	=	14.4 cubic inches / minute
L. O. Cut	=	19. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

Re-enter program at Options for :

1 Shape of Insert (the beginning)
2 Finish and Chip priority
3 Feed
4 Tool Life / Length of Cut
5 Repeat of Results

Exit enter any other key

This page intentionally left blank.

THIS PAGE INTENTIONALLY LEFT BLANK

DISTRIBUTION LIST

COPIES

A. Department of Defense

Defense Technical Information Center
ATTN: TSR-1
Cameron Station 2
Alexandria, VA 22314

B. Department of the Army

Department of Army
Assistant Secretary of Army
ATTN: OSD(PL)
Dr. L. Lehn 1
Pentagon
Washington, DC 21310

Department of the Army
ODCSRDA
ATTN: DAMA-PPM-P/LTC S. Marsh
Room 3C400, The Pentagon 1
Washington, DC 20310

U.S. Army Materiel Command
ATTN: AMCPD-P
5001 Eisenhower Avenue 1
Alexandria, VA 22333-0001

U.S. Army Armament, Munitions & Chemical Command
ATTN: AMSMC-PBS-A 1
Rock Island, IL 61299-5000

U.S. Army Armament, Munitions & Chemical Command
Armament Research and Development Center
ATTN: SMCAR-PMP-P/Mr. Donald J. Fischer, Mr. Glen Knudsen 1
Dover, NJ 07801

U.S. Army Armament, Munitions & Chemical Command
Chemical Research and Development Center
ATTN: SMCCR-PMI/Mr. John Kurtz
Building E5101
Aberdeen Proving Grounds, MD 21010

U.S. Army Armament, Munitions & Chemical Command
Production Base Modernization Activity
ATTN: AMSMC-PB (D)/Mr. Joseph Taglairino, Mr. Richard Koppenaal 1
Dover, NJ 07801

AMC Intern Training Center
ATTN: AMXMC-ITC-E/Mr. Mickey Carter
Red River Army Depot 1
Texarkana, TX 75507

DISTRIBUTION LIST

	COPIES
U.S. Army Management Engineering College ATTN: AMXOM-SE/Mr. Paul Wagner Rock Island, IL 61299	1
U.S. Army Materials & Mechanics Research Center ATTN: AMXMR-PP/Mr. John Gassner Watertown, MA 02172	1
U.S. Army Applied Technology Laboratory Army Research Technology Lab (AVSCOM) ATTN: DAVDL-ATL-ATS/J. Waller Fort Eustis, VA 23604	1
U.S. Army Industrial Engineering Activity ATTN: AMXIB-M/Mr. James Carstens Rock Island, IL 61299-7260	1
U.S. Army Missile Command ATTN: AMSMI-ET/Mr. Bobby Park Redstone Arsenal, AL 35898	1
Rock Island Arsenal ATTN: SMCRI-SEM Rock Island, IL 61299-5000	1
U.S. Army Tank-Automotive Command ATTN: AMSTA-RCKM/Mr. Donald Cargo, Jan Dentel Warren, MI 48090	1
U.S. Army Test & Evaluation Command ATTN: AMSTE-AD-M/Mr. William Deaver Aberdeen Proving Ground, MD 21005	1
U.S. Army Test Measurement Diagnostic Equipment Support Group ATTN: AMXTM-S/Mr. Ken Magnant Redstone Arsenal, AL 35898	1
Watervliet Arsenal ATTN: SMCWV-PPI/Mr. William Garber Watervliet, NY 12189	1

C. Department of the Navy

Commander Naval Material Industrial Resources Office ATTn: Code 044 Code 277 Philadelphia Naval Base Philadelphia, PA 19112	1

DISTRIBUTION LIST

	COPIES
D. Department of the Air Force	
Commander Air Force Materials Laboratory ATTN: LTM Wright Patterson AFB, OH 45433	1

THIS PAGE INTENTIONALLY LEFT BLANK

AD ______________ Accession No. ______

UNCLASSIFIED

Commander, Rock Island Arsenal
ATTN: SMCRI-SE
Rock Island, IL 61299-5000

APPLICATION OF HIGH RATE CUTTING TOOLS
John L. Moriarty, Jr.

Report SE 89-03. 141 p. incl. illus. tables, (AMS Code 3297.06.8248)
Unclassified Report.

Widespread application of the newest high-rate cutting tools to the most appropriate jobs is slowed by the sheer magnitude of developments in tool types, materials, workpiece applications, and by the rapid pace of change. Therefore, a study of finishing and roughing sizes of coated carbide inserts having a variety of geometries for single point turning was completed. The cutting tools were tested for tool life, chip quality, and workpiece surface finish at various cutting conditions with medium alloy steel. An empirical wear-life data base was established, and a computer program was developed to facilitate technology transfer, assist selection of carbide insert grades, and provide machine operating parameters. A follow-on test program was implemented, suitable for next generation coated carbides, rotary cutting tools, cutting fluids, and ceramic tool materials. Computer program algorithms were used to quantify comparisons among different manufacturer's tools. Benefits realized are selective and reduced tool inventory, increased productivity, improved part quality, and more extended, accelerated application of new tooling.

1. Cutting Tools
2. Carbide Tools
3. Machinability
4. Turning
5. Machine Shop Practice
6. High Rate Metal Removal
7. Coated Carbide Inserts
8. Tool Life

DISTRIBUTION

Copies Available from DTIC

AD ______________ Accession No. ______

UNCLASSIFIED

Commander, Rock Island Arsenal
ATTN: SMCRI-SE
Rock Island, IL 61299-5000

APPLICATION OF HIGH RATE CUTTING TOOLS
John L. Moriarty, Jr.

Report SE 89-03. 141 p. incl. illus. tables, (AMS Code 3297.06.8248)
Unclassified Report.

Widespread application of the newest high-rate cutting tools to the most appropriate jobs is slowed by the sheer magnitude of developments in tool types, materials, workpiece applications, and by the rapid pace of change. Therefore, a study of finishing and roughing sizes of coated carbide inserts having a variety of geometries for single point turning was completed. The cutting tools were tested for tool life, chip quality, and workpiece surface finish at various cutting conditions with medium alloy steel. An empirical wear-life data base was established, and a computer program was developed to facilitate technology transfer, assist selection of carbide insert grades, and provide machine operating parameters. A follow-on test program was implemented, suitable for next generation coated carbides, rotary cutting tools, cutting fluids, and ceramic tool materials. Computer program algorithms were used to quantify comparisons among different manufacturer's tools. Benefits realized are a selective and reduced tool inventory, increased productivity, improved part quality, and more extended, accelerated application of new tooling.

1. Cutting Tools
2. Carbide Tools
3. Machinability
4. Turning
5. Machine Shop Practice
6. High Rate Metal Removal
7. Coated Carbide Inserts
8. Tool Life

DISTRIBUTION

Copies Available from DTIC

AD ______________ Accession No. ______

UNCLASSIFIED

Commander, Rock Island Arsenal
ATTN: SMCRI-SE
Rock Island, IL 61299-5000

APPLICATION OF HIGH RATE CUTTING TOOLS
John L. Moriarty, Jr.

Report SE 89-03. 141 p. incl. illus. tables, (AMS Code 3297.06.8248)
Unclassified Report.

Widespread application of the newest high-rate cutting tools to the most appropriate jobs is slowed by the sheer magnitude of developments in tool types, materials, workpiece applications, and by the rapid pace of change. Therefore, a study of finishing and roughing sizes of coated carbide inserts having a variety of geometries for single point turning was completed. The cutting tools were tested for tool life, chip quality, and workpiece surface finish at various cutting conditions with medium alloy steel. An empirical wear-life data base was established, and a computer program was developed to facilitate technology transfer, assist selection of carbide insert grades, and provide machine operating parameters. A follow-on test program was implemented, suitable for next generation coated carbides, rotary cutting tools, cutting fluids, and ceramic tool materials. Computer program algorithms were used to quantify comparisons among different manufacturer's tools. Benefits realized are a selective and reduced tool inventory, increased productivity, improved part quality, and more extended, accelerated application of new tooling.

1. Cutting Tools
2. Carbide Tools
3. Machinability
4. Turning
5. Machine Shop Practice
6. High Rate Metal Removal
7. Coated Carbide Inserts
8. Tool Life

DISTRIBUTION

Copies Available from DTIC

AD ______________ Accession No. ______

UNCLASSIFIED

Commander, Rock Island Arsenal
ATTN: SMCRI-SE
Rock Island, IL 61299-5000

APPLICATION OF HIGH RATE CUTTING TOOLS
John L. Moriarty, Jr.

Report SE 89-03. 141 p. incl. illus. tables, (AMS Code 3297.06.8248)
Unclassified Report.

Widespread application of the newest high-rate cutting tools to the most appropriate jobs is slowed by the sheer magnitude of developments in tool types, materials, workpiece applications, and by the rapid pace of change. Therefore, a study of finishing and roughing sizes of coated carbide inserts having a variety of geometries for single point turning was completed. The cutting tools were tested for tool life, chip quality, and workpiece surface finish at various cutting conditions with medium alloy steel. An empirical wear-life data base was established, and a computer program was developed to facilitate technology transfer, assist selection of carbide insert grades, and provide machine operating parameters. A follow-on test program was implemented, suitable for next generation coated carbides, rotary cutting tools, cutting fluids, and ceramic tool materials. Computer program algorithms were used to quantify comparisons among different manufacturer's tools. Benefits realized are a selective and reduced tool inventory, increased productivity, improved part quality, and more extended, accelerated application of new tooling.

1. Cutting Tools
2. Carbide Tools
3. Machinability
4. Turning
5. Machine Shop Practice
6. High Rate Metal Removal
7. Coated Carbide Inserts
8. Tool Life

DISTRIBUTION

Copies Available from DTIC